

Ohio River Navigation

**Past
Present
Future**



**US Army Corps
of Engineers**

Ohio River Division

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This booklet is designed to commemorate the fiftieth anniversary of the completion of a 9-foot navigable channel on the Ohio River, which was accomplished with the opening of Lock and Dams 52 and 53 in 1929.

The presentation begins with a view of the Ohio River as seen in 1929, and is then divided into three parts, concerned with past, present, and future. The main segment in terms of space is the historical treatment, relating to the development of the waterway.

The arrangement is topical, however, rather than chronological. The objective is a broad view of features of general interest, supported by a selection of photographs, maps, tabulations, and diagrams. For reasons of brevity, many interesting aspects have of necessity been omitted.

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OHIO RIVER NAVIGATION

PAST - PRESENT - FUTURE

The Ohio River as Seen in 1929: The Dream of Half a Century

1929 marked the culmination of a half century of effort to bring about the canalization of the Ohio River, from Pittsburgh to the Mississippi. The occasion witnessed a series of events along the length of the river, beginning with a banquet at Pittsburgh on Thursday, 17 October, and concluding with a session at Cairo, Ill. on the evening of Friday the 25th. These events were coordinated with a dedicatory cruise of the Ohio by a flotilla of steam packets leaving Pittsburgh on the 18th, of which the Steamer *Cincinnati* served as flagship.

President Herbert Hoover, who had taken a keen

and continuing interest in the Ohio River development, personally participated in the dedicatory observances. He dedicated a monument in Cincinnati on 22 October in commemoration of the completion of the Ohio River canalization and traveled to Louisville on the U. S. Lighthouse Tender *Greenbrier*. In his address at Louisville he expressed his pride at being the President who witnessed the "apparent completion" of the river improvement, but saw in the future the need of further development as dictated by advancing technology and new pressures of population.

The display at the right is reproduced from the

**Official Program
and
Complete History**

**Ohio River
Pageant and Dedication**

October 19th-25th 1929

**Commemorating the completion of
the Ohio River canalization from
PITTSBURGH TO CAIRO**

Issued by the
Ohio Valley Improvement Association

Why We Celebrate

THE DREAM OF HALF A CENTURY has been realized. The Ohio River has been completely canalized and periodical interruptions to navigation because of low water are of the past.

The Canalization of the Ohio River is the greatest achievement of its kind in the world. Smaller connecting links, where other forms of transportation are impracticable, are more intensively utilized but, with the exception of the Panama and the Suez Canals, no other natural or artificial watercourse possesses its potentiality.

In its natural state it was one of the great rivers of the world and the chief factor in the development of the Middle-West, playing also an important part in the migration of pioneers to lands beyond.

Not content with this excellent service in the expansion of the nation engineering genius undertook, over fifty years ago, to improve the stream and make it even more useful to mankind. Though opposed by an older generation of river men, practical enough but lacking in vision, the first unit of this gigantic work was put into operation forty-four years ago, giving the harbor of Pittsburgh, for the first time, an adequate all-year stage and converting skeptics into advocates.

It was, unfortunately, not possible then or within the next two decades to procure federal support for the uninterrupted progress of the work. Other projects, practical and visionary, clamored for federal funds and the Ohio River was neglected.

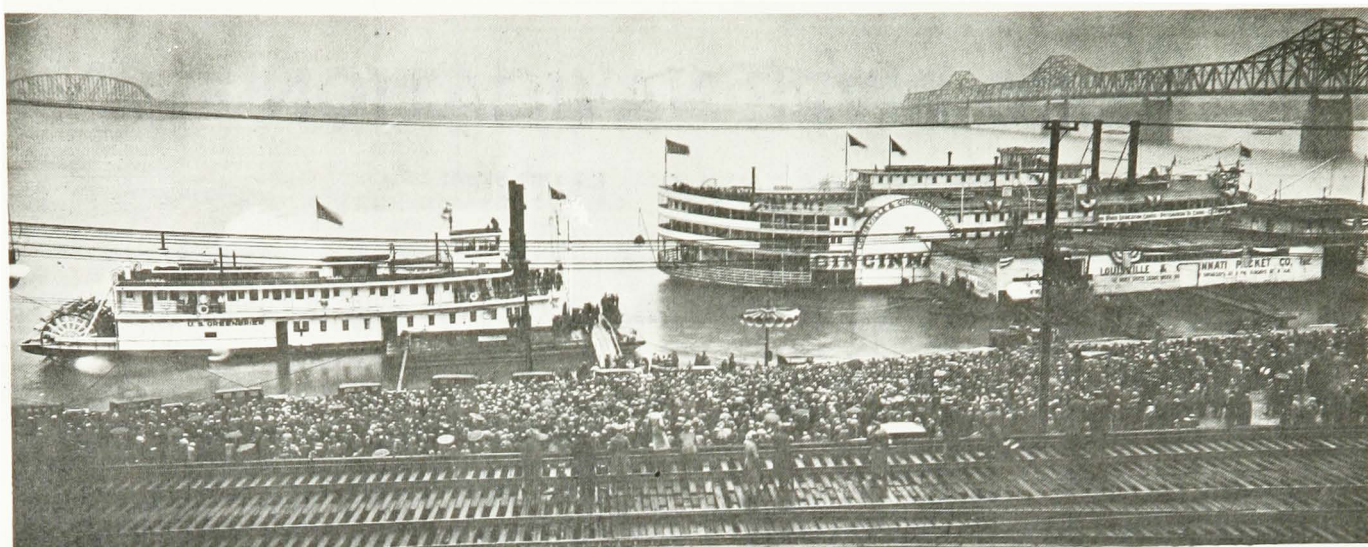
To overcome this condition The Ohio Valley Improvement Association was organized—the outgrowth of a movement of the Cincinnati Chamber of Commerce which soon enlisted the cooperation of other progressive and industrial civic organizations and individuals all along the river.

Under the leadership of the late John L. Vance, of Gallipolis, Ohio, formerly a Member of Congress, and his successors, it was possible for this Association to convince Congress of the outstanding importance of their project and ultimately to bring about appropriations for the regular and progressive prosecution of construction work.

In this the Association has been ably supported by the Corps of Engineers of the United States Army who have served the country as efficiently and as nobly in peaceful as in warlike pursuits and a long line of civilian engineers who have cooperated with the Department.

Now that the great work has been completed The Ohio Valley Improvement Association has invited the President of the United States and other distinguished men and women to join with them and the communities along the river in fittingly celebrating this realization of the dream of half a century. President Hoover and members of his Cabinet have accepted the invitation and a series of appropriate and impressive celebrations has been arranged.

This volume is issued as the official program of these events and a lasting memorial of the occasion.



Caufield & Shook Collection

Riverside reception of the President at Louisville, 23 October 1929

A River Re-Built

As brought to completion in 1929 the canalized Ohio was given a 9-foot navigable depth through its entire 981-mile length. This was accomplished through the construction of fifty dams, creating fifty level navigable pools. Each dam was equipped with a lock 110 feet wide by 600 feet long by which vessels could be raised or lowered from one pool to the next.

In its natural state the Ohio River had proved itself a vital roadway for settlement and for commerce, but with its times of violent flood, alternating with periods of extreme low water, it was both hazardous and unreliable. From low water to flood stage the river could rise thirty to seventy feet in a matter of days. Winter ice conditions also impeded navigation. The most severe ice conditions were found usually in the upper course of the stream, the greatest flood extremes in the middle and lower courses.

The great coal tows which were assembled at Pittsburgh sometimes waited six months for a "coalboat stage" to make possible their heading down the river. And when they were finally on their way, disaster could await them at bars and bends and chutes.

At low water the natural river was obstructed by shifting sandbars, and snags were always a hazard. In dry periods a channel depth of a foot could hardly be

counted on, especially in the upper course of the river.

Canalization provided a dependable 9-foot channel, good in flood and good in drought. Little wonder that the riverusers of 1929 considered the accomplishment of a continuous 9-foot channel a dream come true.

SLACKWATER IMPROVEMENT OF THE OHIO RIVER

FORTY-NINE LOCKS AND DAMS ALL IN OPERATION

LOCKS 600 FEET LONG—110 FEET WIDE

Dam No.	Miles below Pittsburgh	LOCATION With reference to nearest town or other geographical location	Year Construction Commenced	Year Opened to Navigation
3	6.1	Emmeworth, Pa. (Replacing Nos. 1 and 2)	1919	1921
4	10.9	Glenosborne, Pa.	1899	1908
5	18.6	Legionville, Pa.	1898	1908
6	23.9	Freedom, Pa.	1898	1907
7	28.8	Beaver, Pa.	1892	1904
8	36.9	Midland, Pa.	1910	1914
9	46.1	Newell, W. Va.	1904	1911
10	55.6	New Cumberland, W. Va.	1910	1914
11	65.7	Steubenville, Ohio	1912	1915
12	76.3	2.3 miles below Wellsburg, W. Va.	1904	1911
13	87.0	2 miles above Wheeling, W. Va.	1911	1917
14	95.8	McMechen, W. Va.	1901	1911
15	113.8	Woodland, W. Va.	1911	1917
16	128.9	New Martinsville, W. Va.	1911	1916
17	146.4	Ben's Run, W. Va.	1913	1917
18	167.4	4 miles above Marietta, Ohio	1913	1918
19	179.3	4.5 miles above Parkersburg, W. Va.	1902	1910
20	191.4	Little Hocking, Ohio	1908	1916
21	201.7	Belleville, W. Va.	1911	1917
22	213.8	Portland, Ohio	1915	1919
23	220.1	Ravenswood, W. Va.	1915	1919
24	230.6	Millwood, W. Va.	1917	1921
25	242.0	Graham, W. Va.	1913	1919
26	260.0	5 miles above Ft. Pleasant, W. Va.	1917	1922
27	278.0	Hoguen, W. Va.	1908	1912
28	300.3	4 miles above Caponsville, W. Va.	1918	1923
29	310.9	Huntington, W. Va.	1911	1915
30	319.4	3 miles below Charleston, Ky.	1911	1916
31	336.9	3 miles below Greensburg, Ky.	1919	1923
32	358.4	3 miles below Portsmouth, Ohio	1912	1920
33	381.7	1 mile above Rome, Ohio	1919	1925
34	404.0	3 miles above Maysville, Ky.	1915	1921
35	432.8	Ohio, Ohio	1919	1925
36	449.7	1 mile below New Richmond, Ohio	1913	1919
37	459.2	10 miles above Cincinnati, Ohio	1920	1925
38	481.3	Perkins, Ohio	1905	1911
39	501.3	McVie, Ky.	1920	1924
40	529.6	1 mile above Markland, Ind.	1914	1922
41	604.0	Louisville, Ky.	1911	1921
42	630.2	New River Navigation Dam	1925	1927
43	660.3	3 miles below West Point, Ky.	1914	1921
44	699.7	Leavenworth, Ind.	1920	1926
45	732.9	Addison, Ky.	1920	1927
46	772.5	Owensboro, Ky.	1923	1928
47	804.1	Newburg, Ind.	1923	1927
48	838.0	6 miles below Henderson, Ky.	1912	1921
49	867.7	2.5 miles below Uniontown, Ky.	1924	1927
50	893.0	Ford's Ferry, Ky.	1924	1929
51	928.0	Golconda, Ill.	1925	1929
52	951.2	Brookport, Ill.	1924	1929
53		Foot of Grand Chain	1925	1929

* Work on the final dam at Dresden Island, to replace movable Dam No. 3 and 4 is nearing completion.

Tabulation of Ohio River locks and dams in 1929, from Official Program of the dedicatory celebration. Fifty structures are listed

I. Development of the Waterway

Historical Background

Commercial transportation on the streams of the Ohio River basin evolved from the use of the bark and dugout canoes of the Indian.

De Soto's overland expedition from Florida, which touched the course of the middle Tennessee in 1540 on its way to the Mississippi, was apparently the first visit by Europeans to the Ohio basin. The French, however, from their settlements on the St. Lawrence, came to dominate not only the Great Lakes but the upper Mississippi drainage area as well. Fur trading with the Indians was their basic economic interest.

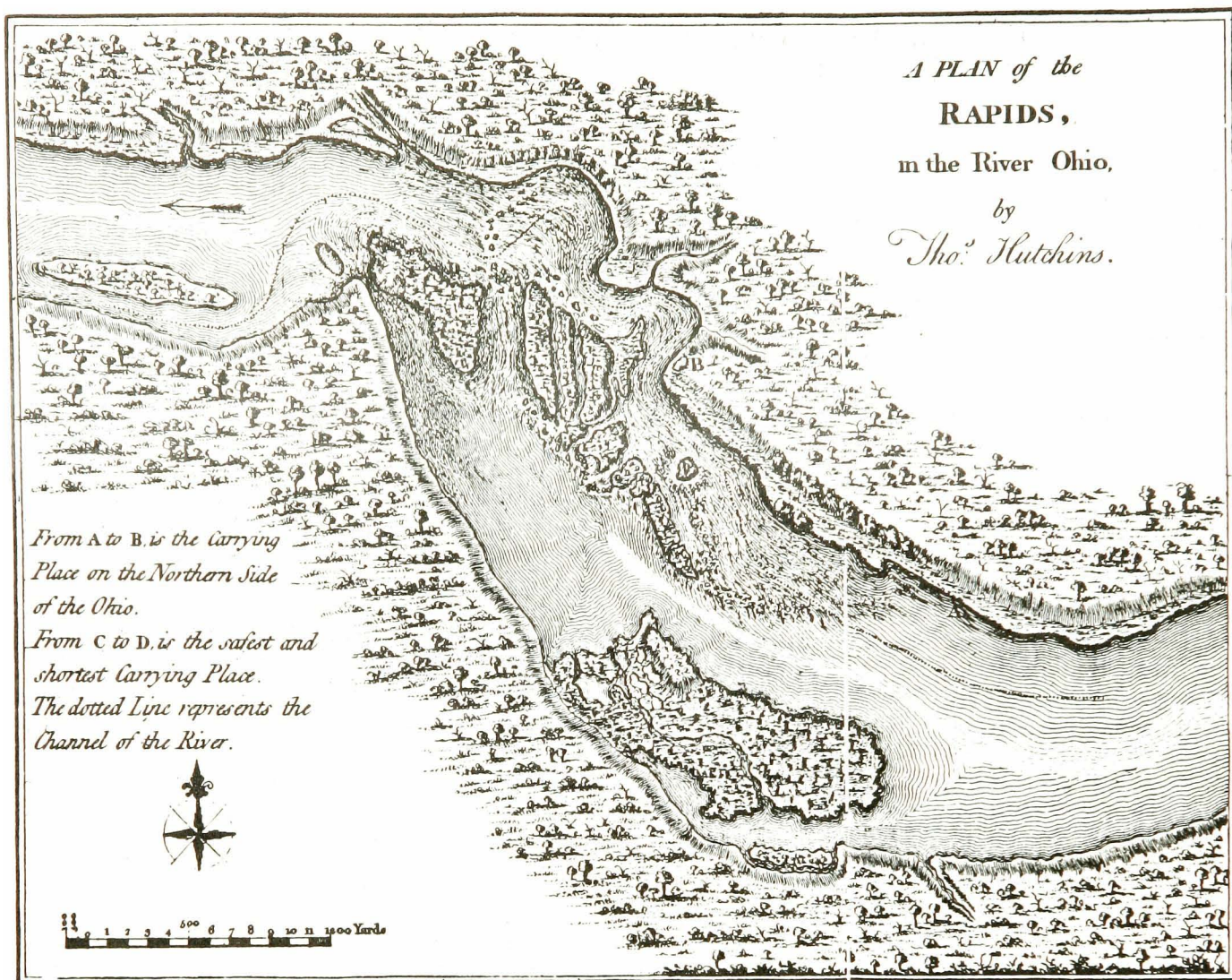
Whether the Ohio River was explored by La Salle in 1669, as long alleged, is now questioned, but it is well established that Arnout Viele, an Albany fur trader, descended the Allegheny and the Ohio in 1692. Even earlier, between 1654 and 1664, northward-flowing tributaries of the Ohio had been visited by Abraham Wood, a fur trader at Fort Henry (later Petersburg, Va.), and in 1671 he sent a trading party to the New River.

By the mid-18th century the Ohio was increasingly frequented by American colonial traders. This circumstance no doubt prompted Celoron's expedition in 1749 to re-claim the Ohio drainage area for the French Crown.

To defend their interests in the upper Ohio country, the French built forts on the Allegheny in 1753. This led Governor Dinwiddie of Virginia to send the twenty-one-year-old Major George Washington to warn the French against encroachment upon Virginia territory. Dinwiddie, on Washington's advice, undertook to have a fort built on "the land in the fork" — the site of Pittsburgh — but the French drove the Virginia militiamen away and built Fort Duquesne in its place. It was this conflict which precipitated the far-ranging French and Indian War. British forces occupied the across-the-mountains area in 1758 and replaced Duquesne with Fort Pitt. The Treaty of Paris in 1763 gave Great Britain the French possessions in Canada and west to the Mississippi.

Celoron's French expedition of 1749, descending the Ohio River. An artist's conception from Virgil A. Lewis' History and Government of West Virginia





Plan of the Falls of the Ohio drawn in 1766 by Thos. Hutchins, an American serving as a British army engineer. Taken from his book, "A Topographical Description of Virginia, Pennsylvania, Maryland, and North Carolina," published in London in 1778. Hutchins later served in the Corps of Engineers of the United States Army

Winning of the Old Northwest

During the Revolution, in 1778 and 1779, a Virginia militia force led by General George Rogers Clark, a leading and aggressive Kentucky settler, took British-held French settlements in the Illinois country. This action was the basis for American claims at the peace table to the area north of the Ohio and west to the Mississippi later designated the Northwest Territory.

Ports of Embarkation

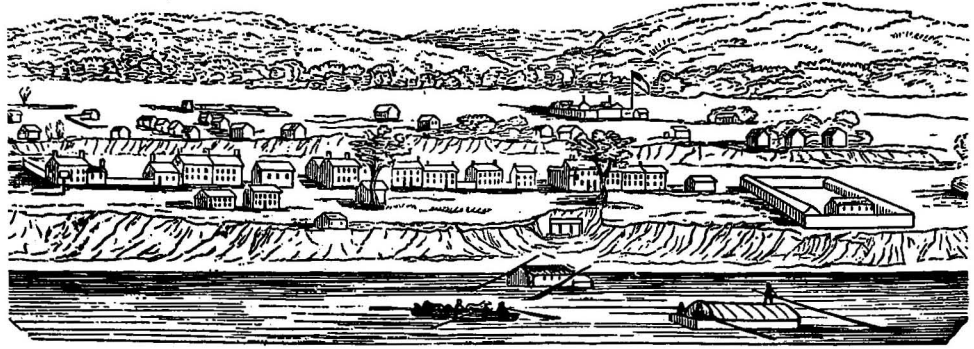
Pittsburgh had its beginning adjoining Fort Pitt in 1764, and following the Revolutionary War the community, strategically located at the head of the Ohio River, became a major port of embarkation for pioneers traveling west, especially those seeking locations in the Northwest Territory. Other river em-

barkation points included Brownsville (Redstone) on the Monongahela, Olean on the Allegheny, Wheeling on the Ohio, and Kelly's Station on the Kanawha. Emigrant families loaded their possessions on flatboats of every size and description and floated down the river to find a place to live.

Settlement of Kentucky

The Bluegrass was the area of earliest occupation in Kentucky. Settlement there began during the first months of the Revolutionary War, and by war's end had grown to 15,000 to 20,000. In 1792 Kentucky, theretofore a part of Virginia, was admitted to the Union as the first state west of the Appalachians. By 1800 about 200,000 settlers are estimated to have traveled the Wilderness Road—marked in 1775 by Boone—while other thousands had floated down the Ohio.

*Cincinnati in 1802, as shown
in Henry Howe's Historical
Collections of Ohio*



Settlement of Ohio

Marietta and Cincinnati were settled in 1788, and settlement north of the Ohio River received a strong impetus with the victory over the Indians at the Battle of Fallen Timbers, in 1794. The influx of settlers was so rapid that Ohio was admitted to the Union in 1803, which was also the year of the Louisiana Purchase.

Boatbuilding

At Pittsburgh, in particular, though at many other points as well, were built the flatboats, keelboats, and

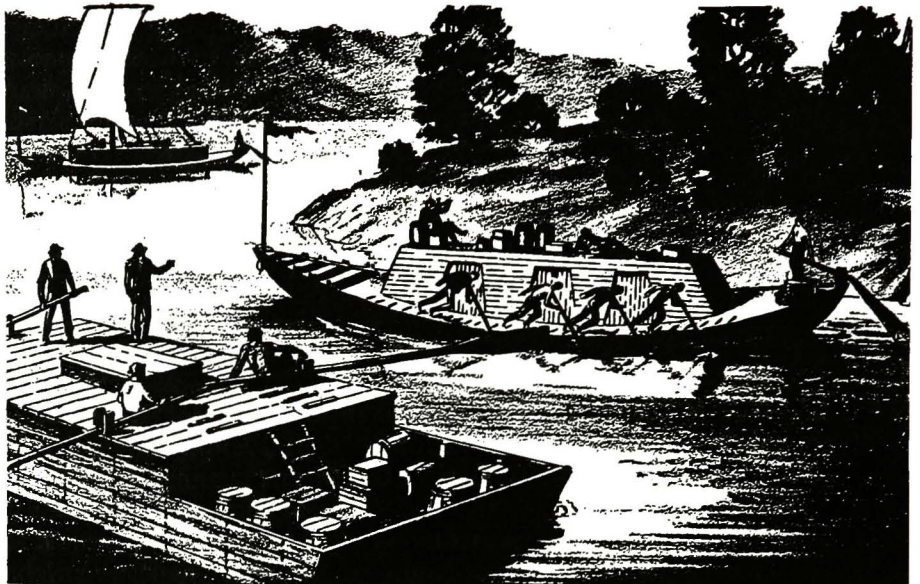
barges that carried the trade of the country downriver. The lumber making up the barges was sold at destination, and the bargemen, many of them, took the long walk back home. Keelboats, however, were used both upstream and down. They were the first Ohio River packets and provided regular passenger and freight service between Louisville, Cincinnati, and Pittsburgh. The round trip between Cincinnati and Pittsburgh might require a month.

From the beginning, Pittsburgh became a dominant center of industry and enterprise. Artisans and enterprisers who undertook boatbuilding were attracted, and with iron ore and coal both available locally, the iron and steel industry got an early start. Even



"Plate the first" of "A General Map of the River Ohio" prepared to accompany Victor Collot's "A Journey in North America." The book was published in Paris in 1826 in French and English editions. General Collot's survey of the Ohio River was begun from Pittsburgh on 6 June 1794

An early scene on the natural river, showing a flatboat and two keelboats



glassmaking was firmly established before the end of the 18th century.

A Merger of Two Eras

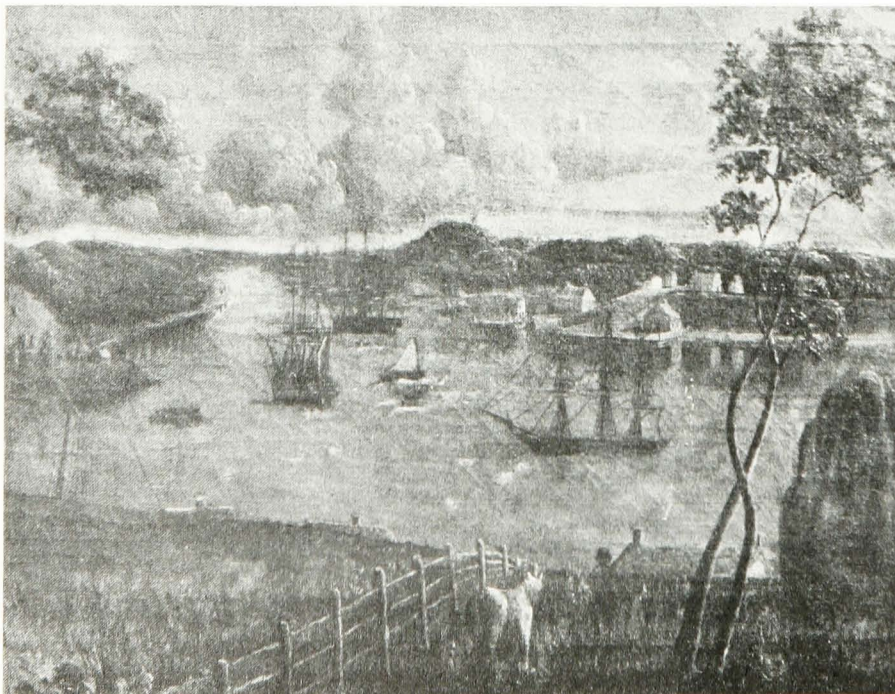
The "historical background" in this booklet ends with the beginning of the steamboat era.

Before the steamboat, flatboats and keelboats were the major means of transportation along the Ohio and its tributaries. The flatboats floated with the current with control limited to steering. The keelboats were the only sizable craft capable of moving cargo upstream. They were poled, pulled, pushed, warped, cordelled, bushwhacked, and even sailed. But the operation was arduous, time consuming, and expensive. As a conse-

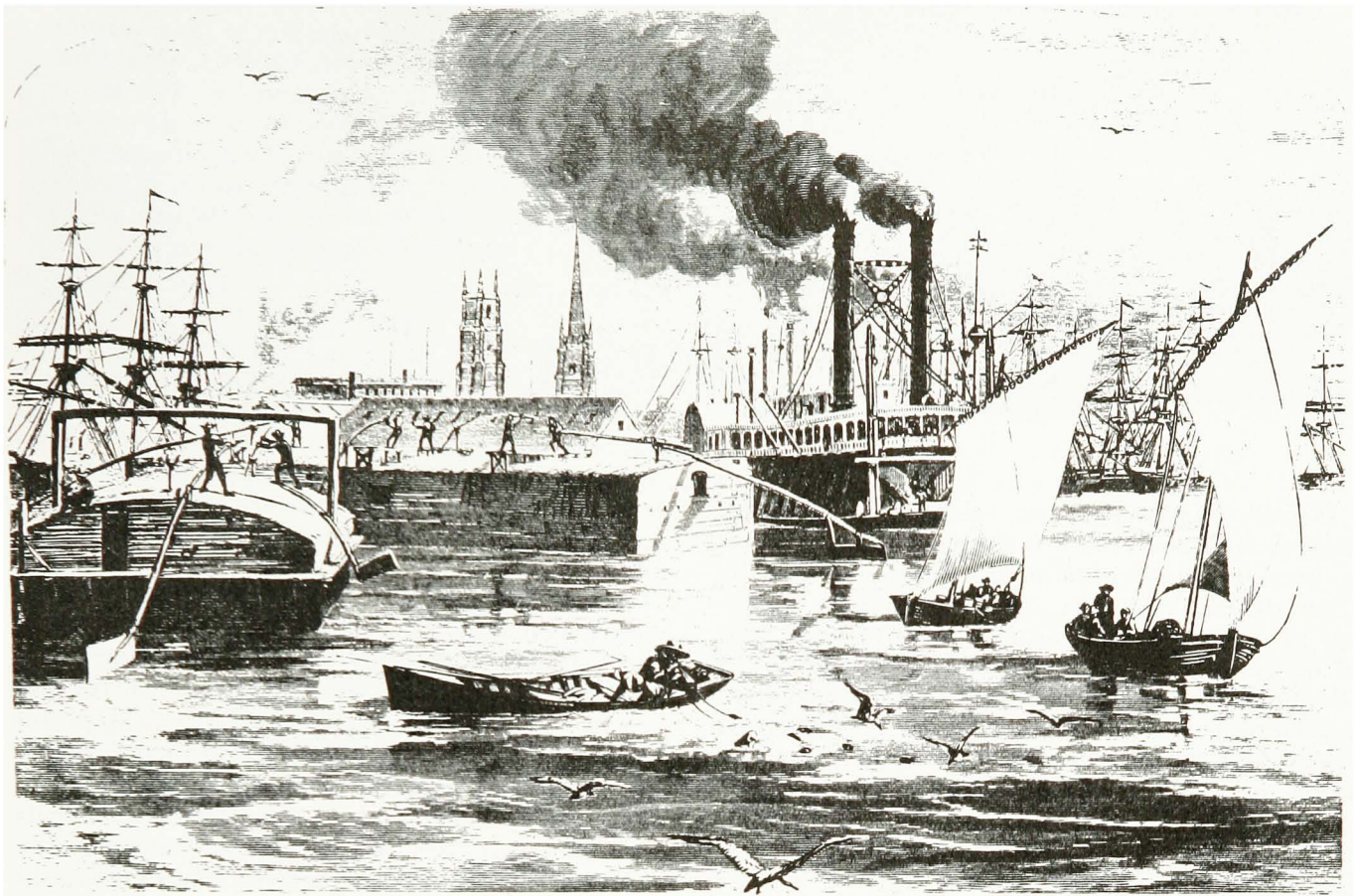
quence, as the use of steamboats, with their greater capacity, economy, and speed, began to develop soon following the War of 1812, the keelboats lost their former special advantage and were soon out of business.

The flatboats, however, continued to prosper. As the Ohio country grew, the need for flatboats was greater than ever. By the mid-1840s 1,200 steamboats were plying the western waters, but there were 4,000 flatboats as well, accounting for close to a third of the total tonnage.

In 1847, the peak year, more than 2,200 flatboats from the Ohio valley landed in the New Orleans area. Thereafter this trade fell off rapidly, though many flatboats continued in use on local and feeder routes.



A seagoing sailing vessel was built on the Monongahela as early 1793. Shown here are oceangoing ships at Marietta. About twenty-five such vessels were built there between 1800 and 1808. From a painting in the Campus Martius Museum.



The Mississippi River at New Orleans as shown in Picturesque America (1872). The commingling of various types of vessels, including oceangoing sailing ships, is notable. New Orleans was the focal point of the economy of the Ohio-Mississippi basin until the railroads tied the interior to the Atlantic coast

Steamboat Era

The first steamboat to navigate the Ohio River was the *New Orleans*, built at Pittsburgh in 1811 by a Fulton enterprise, only four years after the *Clermont* was placed in operation on the Hudson. The *New Orleans* descended the Ohio never to return, but many interests devoted themselves in following years to the development and building of steamboats better suited to use on the inland rivers.

The success of the western river steamboats and their impact on the Ohio valley was largely responsible for the enactment of the first Waterways Improvement Act, in 1824. Before the Civil War the principal function of the Army Engineers in the Ohio valley was the improvement of waterway navigation for the benefit of steamboat commerce.

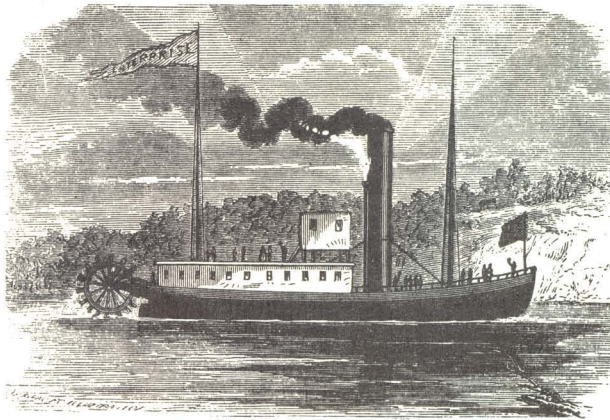
Henry Shreve is credited by historian Archer B. Hulbert with solving the problem of the western river steamboat by designing the *Washington*, "to sail on the water instead of in it, doing away altogether with a hold and supplying an upper deck in its place." The

Washington was built at Wheeling in 1816 and set a pattern for the river steamboats which followed.

With the steamboat, the Ohio became in effect the western extension of the National Road when it reached Wheeling in 1818.

Definition of the Steamboat Era

The steamboat era is not easy to define. Author Frank Donovan wrote that it lasted a century, "fifty years on the way up and a like period on the way down." Paradoxically, he continued, the most glamorous and dramatic part of the era was the period of its decline, a period of floating palaces with gourmet menus and paintings and mirrors hung above "acres" of specially woven Brussels carpet in luxurious main cabins—"the era immortalized in Edna Ferber's *Show Boat* and countless other almost legendary tales of the river boats."



Overall, the river steamboat trade reached its zenith between 1840 and 1860. On the one hand, the beginning and the growth of railroad building and use in the Ohio River drainage area, and on the other the mounting use of mass transportation on the rivers by means of barges and towboats, spelled the decline of the steamboat. The needs once served by the steamboat packets came to an end in the 20th century, with only a few continuing in operation until the Depression of the 1930s.

Change in Trade Direction

Before 1845 the Ohio basin relied basically on the Ohio-Mississippi waterway as a route for market contact. New Orleans served as the focal center for trade not only with the South but with the Atlantic seaboard and abroad.

For thirty years before the Civil War, however, the river route was losing its earlier dominance. First the canals in the 1830s and 40s, then the railroads in the 50s, brought about a redirection of trade from a mainly southern orientation to an increasingly east-west routing.

The Enterprise, of forty-five tons, built at Brownsville on the Monongahela in 1814, was the first steamboat to ascend the Mississippi and Ohio Rivers. Under command of Henry M. Shreve, she carried munitions to New Orleans in December 1814. Vessel and captain were there commandeered by General Andrew Jackson for varied duties in preparation for the Battle of New Orleans, which occurred 8 January 1815

The river commerce lost much of its interregional character and became more largely regional. The development of roads, canals, and railroads, in combination with burgeoning commerce in the Erie Canal-Great Lakes region to the north brought about an ever growing and an ever changing transportation structure.

The decline of the rivers was relative, however, rather than absolute. The rivers continued important in freight movement—though of diminishing use in passenger travel—right up to the beginning of the war.

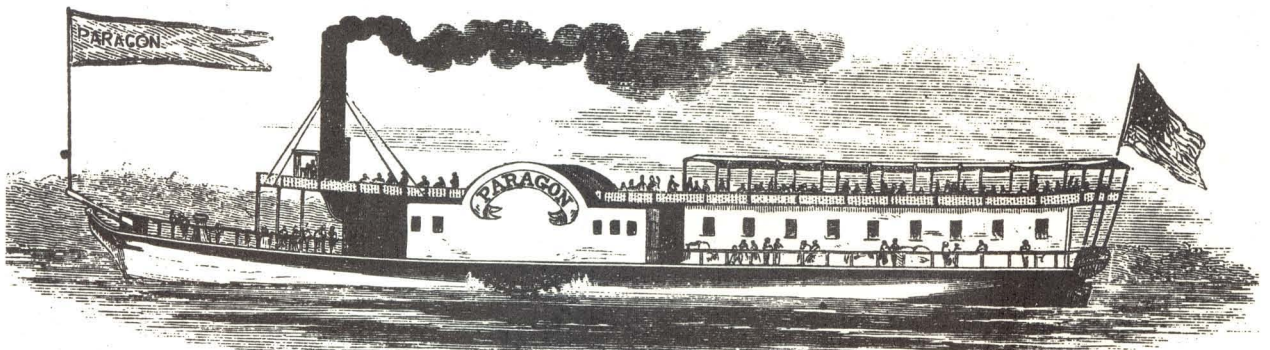
The Civil War disrupted normal traffic on the inland rivers, and the Mississippi below Cairo was closed to commercial use. Ironclad gunboats were built at St. Louis and Cincinnati, and the majority of steamboats were used as transports for troops and supplies.

Rebuilding of traffic on the rivers following the war was slow, and many readjustments took place. But there was a resurgence of steamboat traffic. The general trend was upward until about 1880.

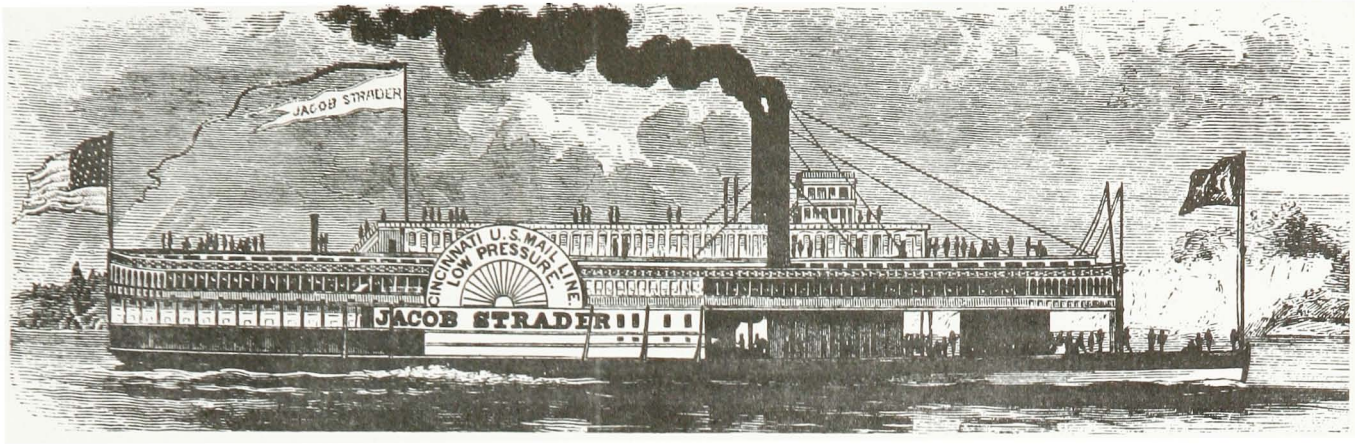
Measure of Steamboat Use

As summed up by Leland Johnson in his history of the Huntington District of the Corps of Engineers:

Nearly 6,000 steamboats were built along the inland rivers between 1820 and 1880, and, from first to last, about three-fourths were built in the Ohio valley.



The Paragon (355 tons), built at Cincinnati in 1819, was, in her period, one of the largest and finest boats on the inland rivers. Hunter states that "within a year of her maiden voyage she had completed the trip from New Orleans to Louisville with full cargo in seventeen days and seven hours"



The Jacob Strader, 905 tons, was built in Cincinnati in 1853 for the Cincinnati and Louisville Mail Line. With a length of 347 feet she was the largest boat on the river. The hull, with a width of 27-1/2 feet, supported a main deck 69 feet wide

The steamboat construction boom gave an enormous boost to Ohio valley industrial development, and the speedy, economical transportation the steamboats furnished accelerated commercial growth and ended the frontier isolation of the region.

Imposing three-decked steamboats carrying several hundred passengers came to be a common sight.

The 50s were the bright years of steamboating in terms of amount and quality. But the decade was marked by depression and misfortune and the beginning of the trend toward decline.

Design of the Western Steamboat

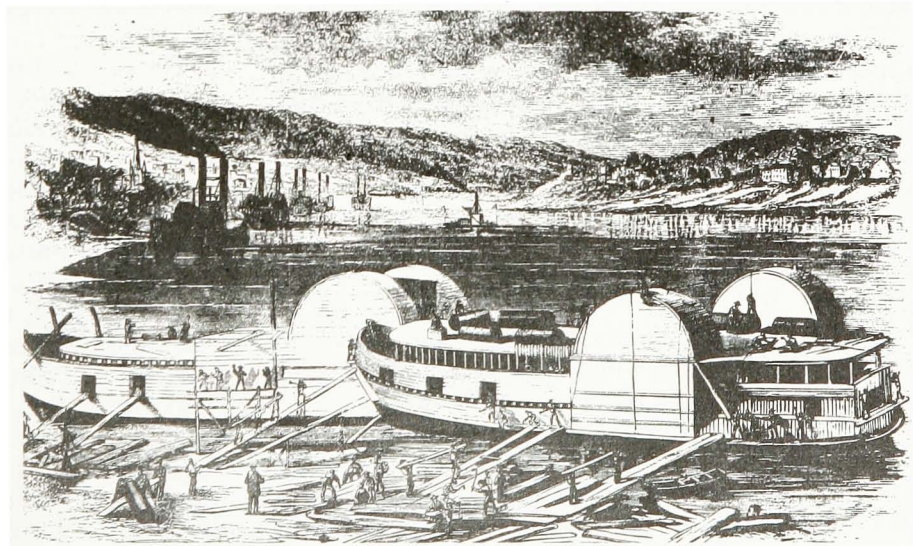
For operation on the western rivers the steamboat builders evolved a flat-bottomed vessel of great buoyancy, the hull long and slender, with the ends modelled for an easy entry and run.

The features of design of the typical main-line steam packet are described by Alan L. Bates in the September 1966 issue of the *S & D Reflector*. The guiding principle: "The boat that could run a week earlier and continue a week longer was a winner at the cash box." These boats made good speed, and saved time, too, because of fewer groundings.

The hull was six to nine times as long as it was wide and forty to fifty times as long as it was deep. To stiffen the flexible and lightly built wooden craft the hogchain system of bracing was developed. Hogchains were wrought iron rods firmly fitted at the forward and after ends of the hull and led up over tall timber braces. The purpose and effect was to keep the ends of the boat from sagging.

The main deck was wide open, with all space not occupied by boilers and machinery used for stowing freight. The passenger cabin, above the main deck, consisted of a center hall or grand saloon, running nearly the full length of the boat, flanked by compact

Steamboats in the Civil War period. Gunboats being fitted out at Cincinnati for Union service on the Mississippi. From Harper's Weekly, 13 July 1861



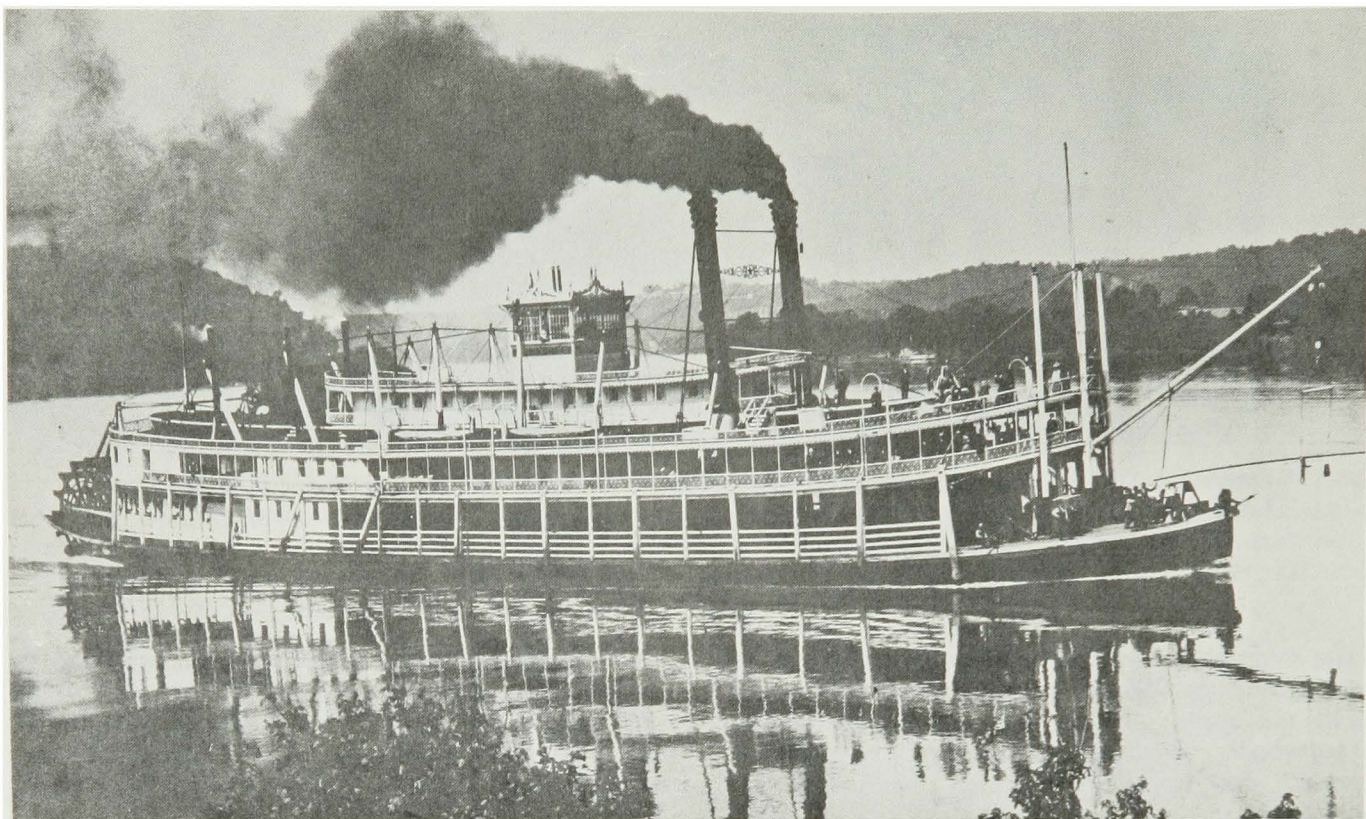


Photo portrait of the Queen City taken about 1900, while piloted by Captain Anthony Meldahl. The Queen City was built in Cincinnati in 1897 for the Pittsburgh and Cincinnati Packet Line. The vessel was 235 feet long and 44 feet wide (51 feet over the guards). The main cabin, 200 feet long, was finished in burnished mahogany. The photograph brings out the intricate hogchain system. The boat sank twice, in 1909 and 1914, and spent its last days, to 1933, as a wharfboat at Pittsburgh. The engines of the Queen City were second hand. They were constructed in 1880 for the Florida, a sidewheeler built in Sewickley and Pittsburgh for the Savannah-Jacksonville trade. According to the S & D Reflector "the old Florida engines were picked up in Florida for \$100 plus rr. charges to Cincinnati"

and simply fitted staterooms on each side. A broad sheltered promenade surrounded the cabin and staterooms.

The impression of luxury was limited to the center hall, which served as dining hall as well as social center.

Twin smokestacks were used, giving a balanced appearance to the boat while leaving the grand saloon unimpeded. The sheer curve—the rise in the main deck at bow and stern, designed to prevent waves from washing aboard—added grace to the vessels and was repeated all the way to the highest roof.

Variations among Steamboats

Actually, the steamboats presented many variations in size and appearance, some of them leaning decidedly toward simplicity and plainness—even ugliness.

Of necessity, smaller steamboats were developed for use on tributary streams such as the Muskingum, the Kanawha, the Little Kanawha, and the Guyandotte. A small side-wheeler type known as the batwing came to

be particularly identified with the Big Sandy, including the Levisa Fork.

Wood the Favored Material

The merit of iron hulls for steamboats began to be recognized about 1825, but on the western rivers, wood, the familiar and abundant material, continued to be used for virtually all commercial vessels. The low first cost of wooden hulls appeared to be the compelling factor, even though the iron hulled vessel might be expected to outlast five or more wooden ones. What with sinkings from snags, collisions, groundings, fire, and explosions, the average life of the western river steamboat was reckoned at only five or six years.

It was not until about 1880 that a Pittsburgh firm began to specialize in building steel hulled vessels. And most of those boats were built for export. As found by Louis Hunter, as late as 1906 only about 5 percent by number and 10 percent by tonnage of the western river boats had hulls of iron or steel.

Channel Development

By reason of its very existence, located as it was — and is — the Ohio River provided an easy water highway to the west, serving to funnel the movement of settlers and of the country produce which soon sought a route to market.

The Ohio was easy, however, only when compared with overland routes, and especially the rugged and difficult roads across the Appalachians. As described in the historical preface of *The Ohio River*, issued by the Chief of Engineers in 1934:

In its original condition, the Ohio River was much obstructed throughout its entire length by snags, rocks, and gravel and sand bars, rendering navigation difficult and hazardous. The width of channel was exceedingly variable. The depth available for navigation over the worst shoals at extreme low water varied from a minimum of 1 foot between Pittsburgh, Pa. and Cincinnati, Ohio (470 miles), to 2 feet between Cincinnati and the mouth of the river (511 miles). When the depth over the worst shoals was 3 feet or more, the river was navigable throughout its entire length for steamboats and other craft, except as its use was affected by floods or ice.

Federal Aid to Inland Navigation

The first Inland Waterways Improvement Act, signed 24 May 1824 by President James Monroe, directed that experiments be conducted to determine the best method of coping with sandbars in the Ohio River and that measures be taken for the removal of snags obstructing navigation on the Ohio and

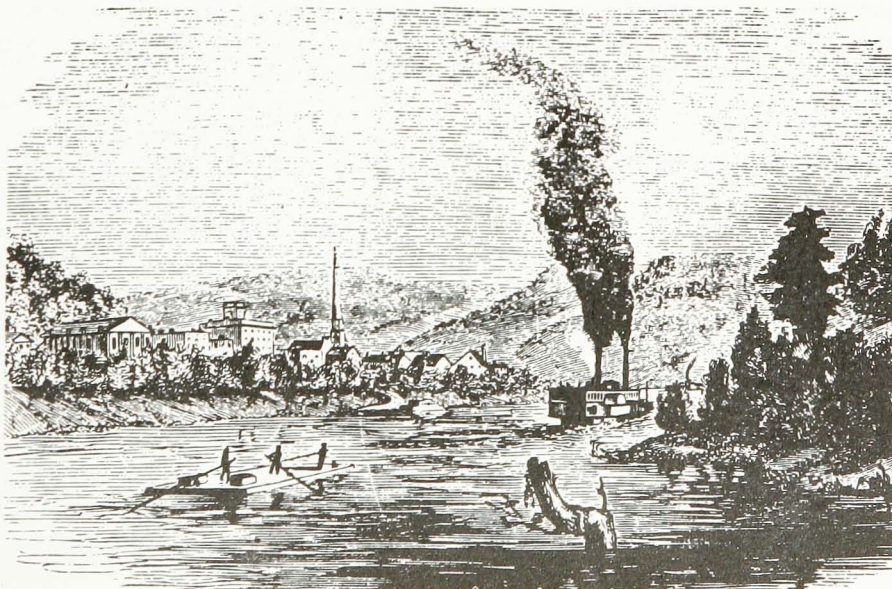
Mississippi Rivers. The Army Corps of Engineers was put in charge of this work, and three years later the Secretary of War was given the responsibility for supervising and directing improvements on all navigable waters.

The Chief Engineer of the Army established a public competition in June 1824 for the best “plan, machine, or instrument” for the removal of snags. Removal of snags and other obstructions was vitally necessary in protecting vessels against damage or loss, and, until construction of the slackwater system of navigation on the Ohio was begun in 1877, the use of cutoff dams on back channels and of wing dikes to concentrate flow in the main channels provided the principal means of improving the navigable depth. The wing dams, when adequately provided, were generally effective in assuring a minimum channel depth of 3 feet.

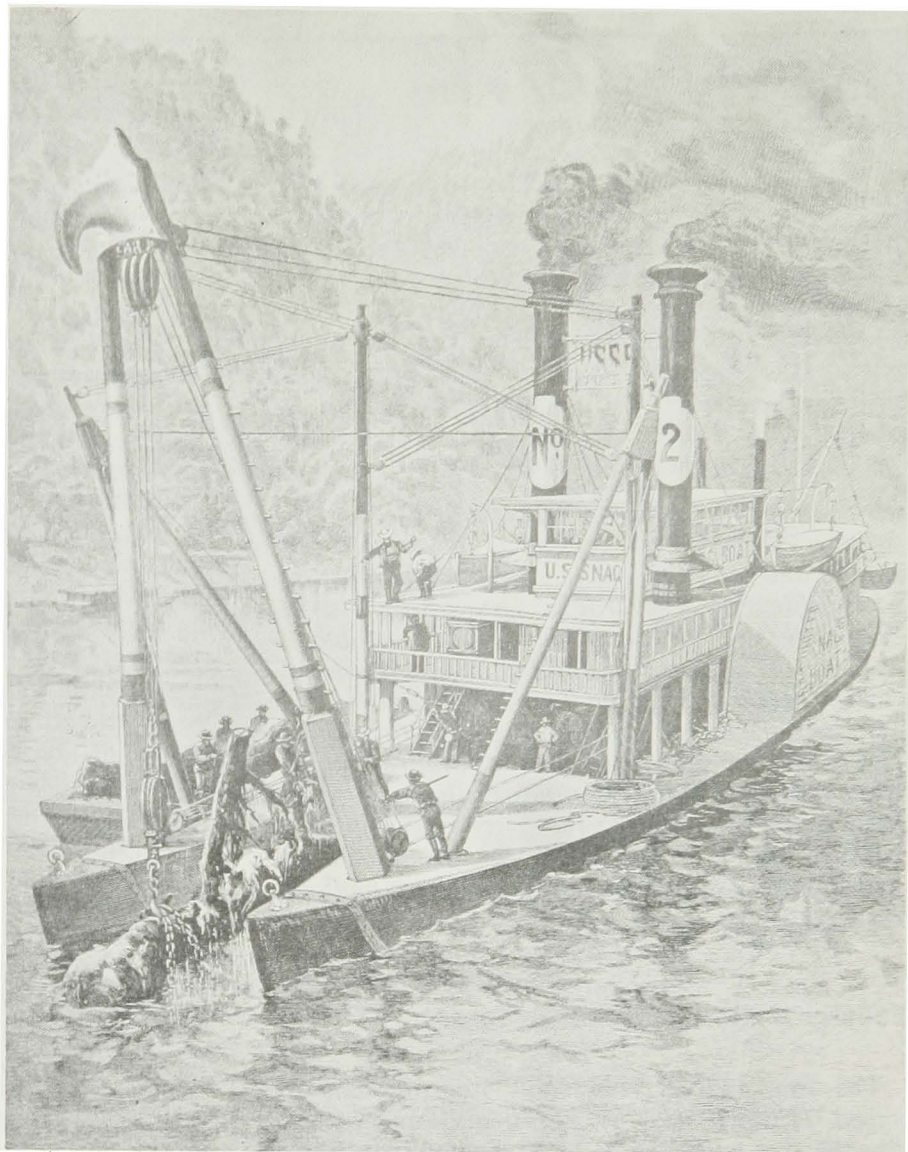
From 1826 to 1844 appropriations for the improvement of the Ohio were made with approximate regularity, but then, under contrasting political leadership, and during the Civil War, from 1845 to 1866, only two appropriations were made, one quite small, the other for \$95,000.

The first wing dam or training dike was begun at Henderson Bar in 1825. Removal of rocks from Grand Chain was begun in 1830. Dikes were begun at Scuffletown and Sisters Islands in 1831, and at French and Cumberland Islands, all downriver from Owensboro, Ky., in 1832. No work except snag removal was done above Louisville until 1836, when dams were begun at Brown Island. The success of these works was such that a large number of wing dikes and back channel dams were subsequently built between Pittsburgh and Cincinnati up until the general stoppage of work in 1845.

River traffic at Steubenville at an early period. From an old print



U. S. Snagboat No. 2, a single-hull, double-bow design. This was one of five snagboats for which Congress made provision in 1852. From Harper's Weekly, 2 November 1889



Channel Work Resumed

Marking a new era in the development of inland navigation, appropriations for improvement of the river were resumed in 1866. The work of open channel improvement has been continued as required from that time on.

Keeping the Channel Clear

Excerpts from the report of Colonel William E. Merrill for fiscal year 1888 will serve to exemplify the procedures and problems of channel maintenance and development on the Ohio before canalization. It shows that the snagboat *E. A. Woodruff* traveled the river 2,125-1/2 miles during the operating season, removing "1,225 snags, 127 large rocks, and 16-1/2 cubic yards of riprap, 46 new wrecks, and the remains of 13 wrecks, previously reported." One of the snags removed weighed 164 tons.

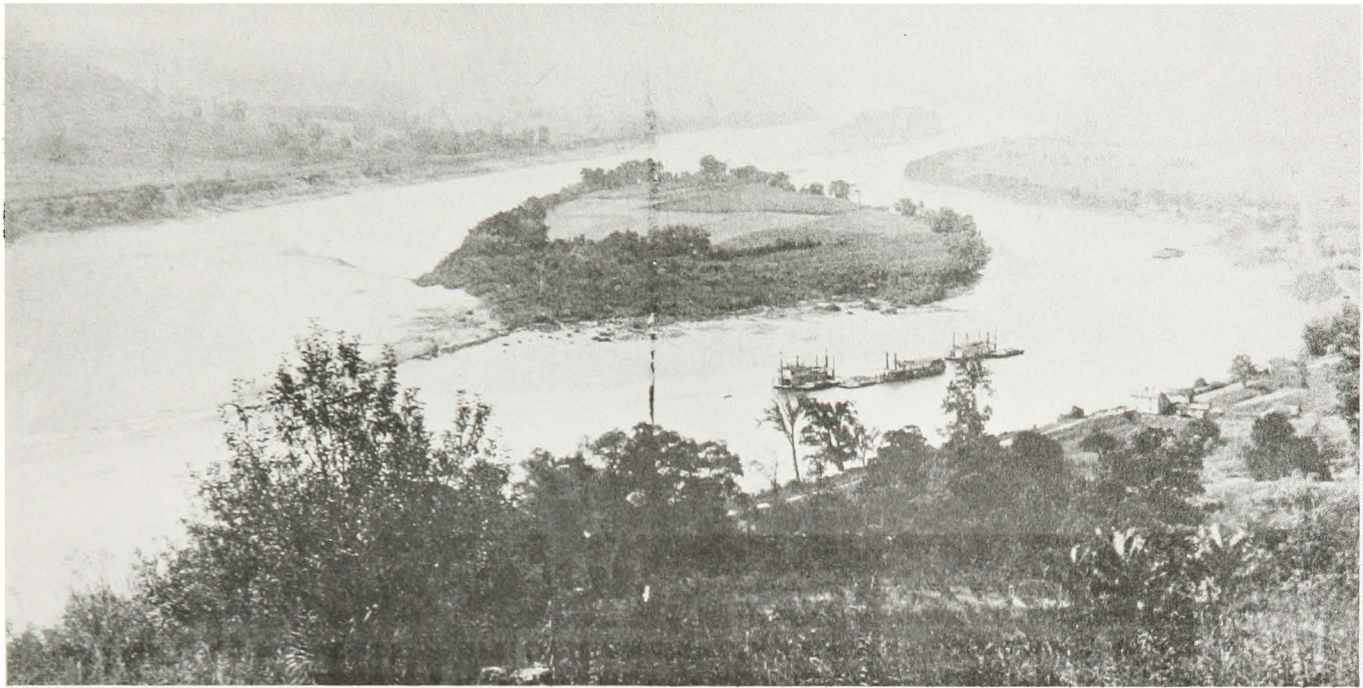
"Among the wrecks the most notable were those of

the wharf-boat at Huntington, W. Va.; the steamer *Jerry Osborn*, near Catlettsburgh, Ky.; the steamer *Good Intent*, at Lewisport (Ky.) Landing; the ferryboat, opposite Paducah, and the steamer *Charles Morgan*, from the harbor at the upper end of Cincinnati."

"During the summer and autumn of 1887 the Ohio River was continuously at a very low stage for the longest period ever known since regular gauge-records have been kept. During all this period of extraordinary low water the *Woodruff* was continuously at work, and was the only steam boat in commission on the river. She frequently had to spar her way over bars, and it took her four days to get over the bar at French Island; but she kept steadily at her work until she reached Cincinnati in the latter part of October. . . ."

"It was possible to have continued work above Cincinnati, but coal was at famine prices, and almost impossible to get at any price, and the occasion did not seem to call for unusual expenditures or risks."

The report also describes the work of Corps dredges



U. S. Dredges Ohio and Oswego at work at Three Brothers Islands, at about River Mile 158.4, 25 August 1887. A downstream view from Mount Dudley. The site of the present Willow Island Locks and Dam is in the distance

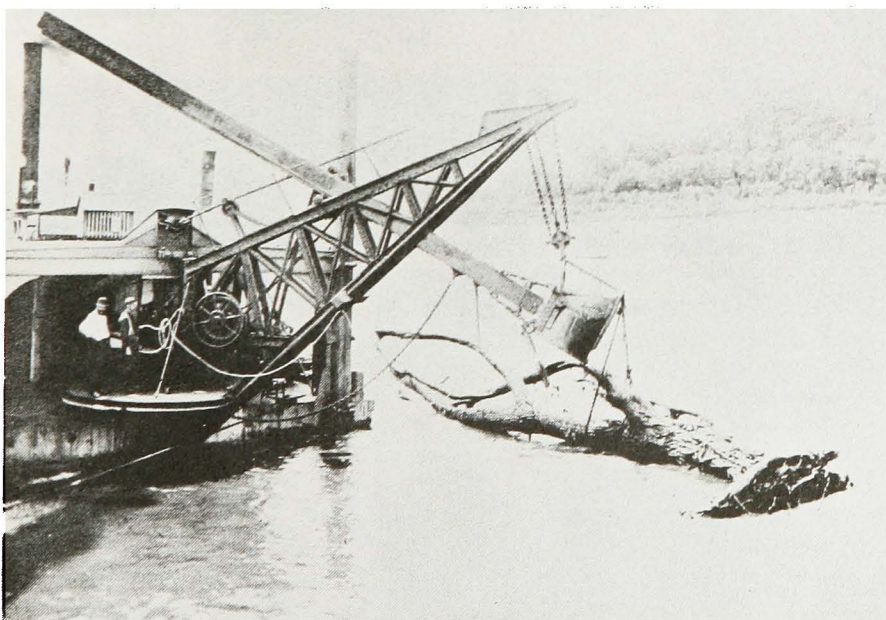
on the Ohio River in 1887, the work undertaken under contract for the removal of obstructions and in the building of dikes, and various problems of river development, all in considerable detail. Tabulations are also given on such subjects as the slope of the Ohio River at low water from Pittsburgh to Cairo, gage data, effects of ice on navigation, locations and status of dams and dikes, bridges over the Ohio, improvement contracts in force, statistics on river commerce, arrivals and departures of steamboats at Cincinnati,

commerce passing the Falls by canal and by river, and vessels passing the Davis Island Dam.

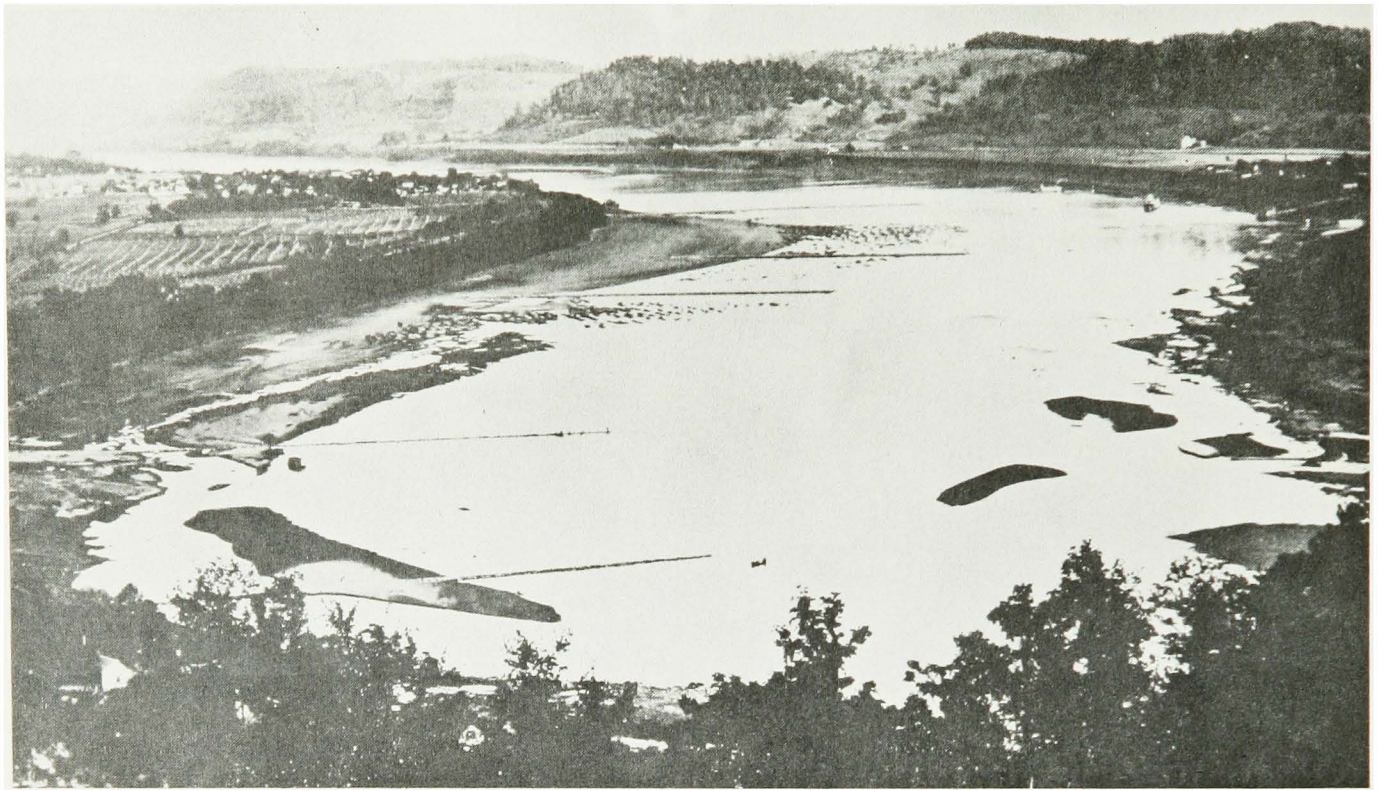
The report is representative of the annual Engineer reports issued in the period.

Channel Maintenance after Canalization

Canalizing the river through the construction of locks and dams did not end the need for dredging.



An Ohio River snag being removed by a dredge in the 1885-93 period



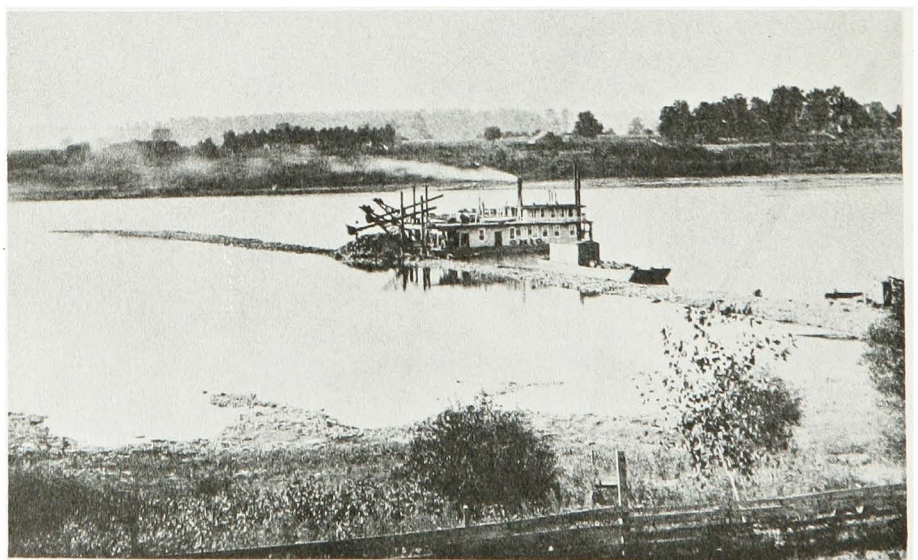
Ohio River as seen during a dry spell in the 1890s. The picture is an upriver view from the top of the hill (Seven Hills Farm) opposite Huntington, across from the former 26th Street ferrylanding. Five stone training dikes show prominently. The two nearer at hand were built about 3 feet high, so the river stage may be taken at about 2 feet. Overlooking the river in the distance, left of center, is Proctorville, Ohio

River currents are constantly shifting sediments downstream, especially during floods, and shoals and bars are in constant process of relocation. Vessel movements also produce water movements which alter the configuration of the riverbottom.

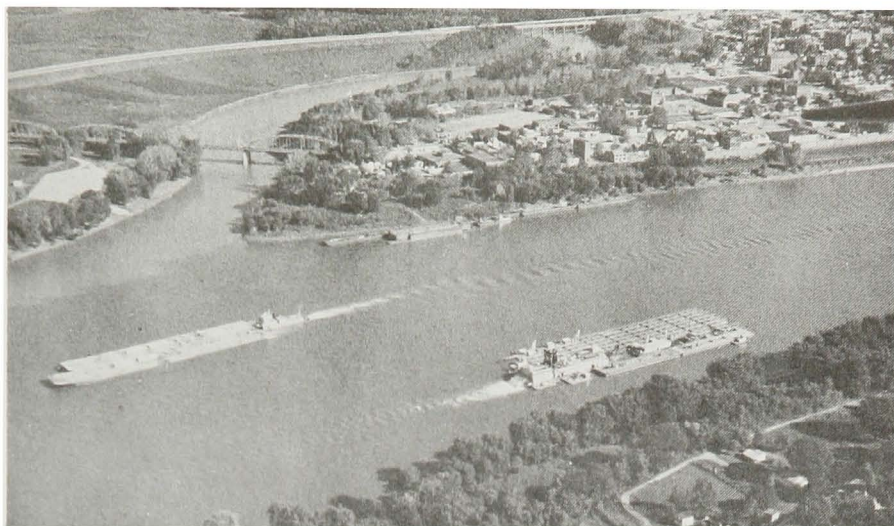
To maintain channels for navigation, dredging is a continuing necessity. This is carried out by the Corps of Engineers primarily through contractors.

Open channel work on the Ohio River consists of removing obstructive bars and shoal areas within the various navigation pools to maintain a project operational depth of 9 feet and a minimum channel width of 300 feet as authorized for the present canalization system. The amount of material dredged depends upon the amount of sediment deposited in the channel during the high-water season and varies from season to

Dredges removing outer end of Rising Sun Dike (thirty-five miles below Cincinnati), September 1884



The Corps of Engineers suction dredge Ste. Genevieve, with barges, heading up the Ohio River near the mouth of the Scioto River at Portsmouth. Heading downriver is a tow of empty tank barges. At the right may be seen a portion of the Portsmouth floodwall



season.

Immediately following the construction of a dam there is a period during which little dredging is required within the new pool. Eventually the dredging requirements return, however, at least to pre-dam levels.

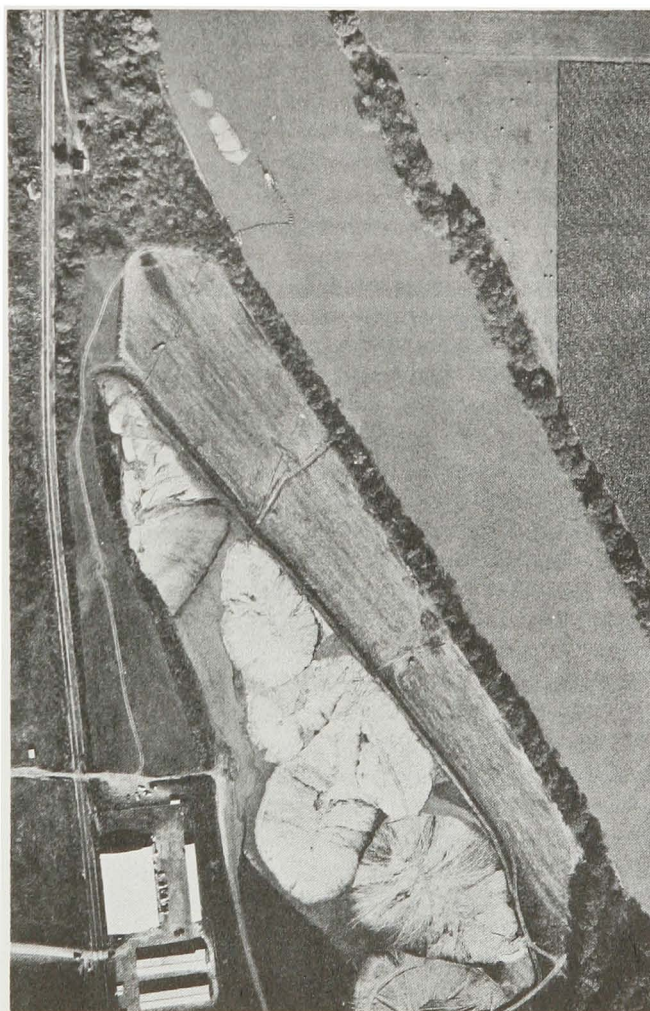
It is well understood that a prescribed navigable channel depth—of 9 feet for example—requires dredging to a depth greater than that specified, varying according to anticipated rates of sedimentation, potential pool fluctuation, and possible severe ice conditions. Otherwise, grounding of vessels would be a frequent occurrence—with resulting damage and delay—and emergency dredging and emergency recovery operations would become routine.

Charts and Navigation Aids

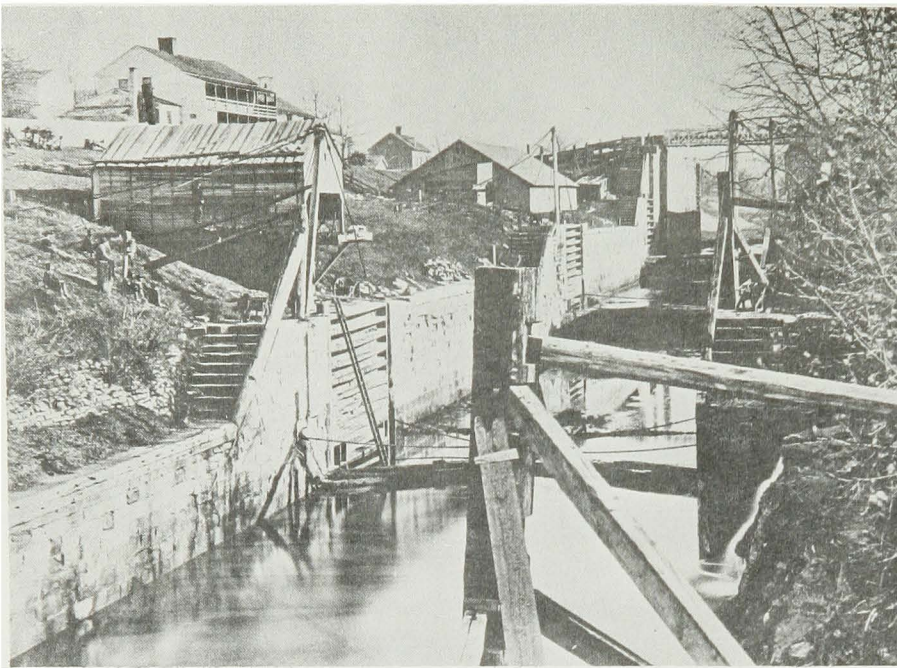
Navigation charts are issued annually by each of the Corps Districts, identifying the channel sailing line, mile points, locks and dams, bridges, underwater and

aerial pipeline and wire crossings, aids to navigation, river terminals, boat ramps, and industrial and other installations potentially affecting navigation.

Aids to navigation, including buoys, lights, and daymarks, are installed and maintained by the U. S. Coast Guard.



A vertical aerial view of a suction dredge clearing sand deposits from the Big Sandy River near Catlettsburg, October 1975. The dredged material is being pumped to a diked disposal area on low ground near by on the Kentucky side of the river. The disposal area became the site of the Catlettsburg pilot coal liquefaction plant, built under government sponsorship



The original three-flight locks of the Louisville and Portland Canal, opened in 1830. Photograph from Record Group 77 of National Archives. Probably taken in 1874

Falls of the Ohio

Falls of the Ohio is without doubt a misnomer. Yet the rapids called by that name formed the only major obstacle to navigation on the Ohio River, and their existence occasioned the location there of a thriving break-bulk community which has become the present city of Louisville.

Earliest River Improvement

The rapids extended about two miles, dropping about 26 feet at low water, and navigation over the falls could not be undertaken except at high water stages. It was but natural, then, that the first structural improvement on the river was the building of the Louisville and Portland Canal—bypassing the Falls—which was opened on 5 December 1830. The need for the canal had become compelling with the growth of steamboat commerce on the river following the War of 1812. Even earlier, at the request of Henry Clay and other congressmen from the Ohio valley, study of canal projects at the Falls was authorized as part of the comprehensive study of American transportation problems conducted in 1807 under the direction of Secretary of the Treasury Albert Gallatin.

In its natural state the Falls of the Ohio included three channels, or chutes, the Indiana Chute near the north bank, a Middle Chute, and the Kentucky Chute along the south bank. As the river rose, the Indiana Chute became navigable first, followed by the Middle Chute and finally the Kentucky Chute. At the outset, two projecting rocks in the Indiana Chute, about 15 feet apart, practically standardized descending flat-

boat traffic at a width of 14 feet. At the highest stages, the river gradient was so reduced as to permit navigation with relative ease, but such high stages ordinarily occurred during less than two months of any single year. For the remainder of the year the white water rapids of the Falls made navigation exceedingly hazardous if not impossible.

At low water seasons, waterborne commerce was interrupted, and a drayage industry flourished between Louisville and Shippingport, at the lower end of the rapids. Not long after Louisville was founded in 1778, professional Falls pilots were in business, guiding waterway traffic over the Falls.

The canal, when built, was 1.9 miles long and was equipped at its lower end with a flight of three lock-chambers, each measuring 50 feet by 185. The canal itself was 64 feet wide. A navigable depth of 3 feet was provided at low water.

The building of the canal was undertaken by a private stock company, chartered by Kentucky in 1825. From the beginning, however, nearly 40 percent of the stock was owned by the United States government. This share was gradually increased until in 1855 all of the stock was owned by the government except for the five qualifying shares held by the directors. Even those shares were acquired in 1874, and the government then assumed full control of the project. In 1880 the collection of tolls was discontinued.

Techniques of Building

As observed by Leland Johnson in his history of the



Rebuilding of the Louisville and Portland Canal, 1873. Photograph from Record Group 77 of National Archives

Louisville District, the techniques used for construction of the Louisville and Portland Canal did not differ materially from those used on the Egyptian pyramids and the Roman aqueducts. Like the ancient builders, the contractors for the canal relied on human and animal power. Excavation was accomplished with handtools, oxen-drawn plows, and scrapers dragged by horses; and the excavated materials were removed in wheelbarrows and horse-drawn carts. Gunpowder was used for rock excavation in the 19th century work, however.

The walls of the locks and canal were constructed of cut stone masonry, stone for the project being quarried a few miles below the site and transported upriver. As it developed, limestone taken from the lock pits came to be used in the production of cement for use as mortar in binding the masonry in the lockwalls together. The manufacture of hydraulic cement was later to become an important industry in the Louisville vicinity.

Problems of Operation

Flatboats passed through the canal in early December 1830, and on December 21 the first steamboat, the *Uncas*, locked through bound for Nashville. One of the first vessels to use the canal was a flatboat from Cleveland which had navigated the Ohio and Erie Canal and the Muskingum River to Marietta and proceeded down the Ohio on its way to New Orleans.

During the first 104 days of operation, 827 boats, 406 of them steamboats, locked through the canal.

Among the numerous problems experienced in the operation of the canal was the fact that deposits of mud and debris were left in the canal and in the locks after each flood. The flood of 1832, which left a number of wrecked houses in the canal, required extensive repairs

and alterations to the project. In 1833 a steam-powered dredge was built to remove mud and debris.

Though the canal served a great and vital need, its limitations soon became evident. The lockchambers were designed for vessels used on the rivers in the 1820s and limited the hull dimensions to 183 feet long by 49-1/2 foot beam. By 1853 more than 40 percent of the steamboats on the Ohio were too large to pass through the canal. Steamboat designers had also increased the draft of their vessels in order to enlarge their cargo capacity. The principal objection to the canal on the part of rivermen was, however, the tolls charged at the canal, and these were the subject of much dispute and occasional change.

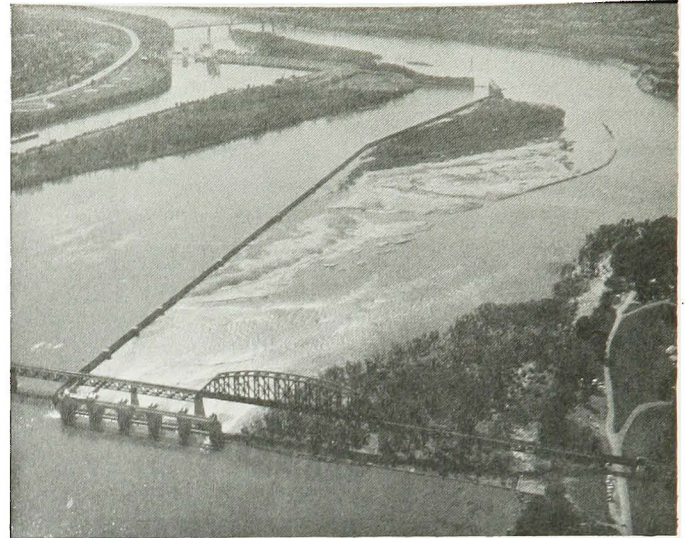
By 1840, the majority of those interested in the canal supported national ownership and operation, in the interest of reducing the tolls, or eliminating them. Others advocated federal aid to improve open channel navigation over the falls, and still another group favored the building of a second canal along the Indiana bank.

From 1868 to 1872 the canal was widened and the original three locks were replaced with two larger ones, each 80 feet by 325. In 1881 a timber-crib dam was completed, raising the pool above the rapids by about 3 feet, to improve navigation through the canal.

In the 1881 to 1901 period, 135,630 boats, carrying cargoes aggregating 37 million tons, locked through the canal. The annual average was 6,780 boats, and 1.8 million tons. About three-fourths of the tonnage was coal. Traffic congestion was a major problem. As an instance, on 6 July 1902, towboats pushing 461 barges arrived at the canal. It required 213 lockages to get these through to the lower river. The last barge was locked through on 17 July, only seventeen hours having been devoted to the moving of other traffic.

To enable coal-tow passage over the Falls and avoid the delays of lockage, rock excavation was under-

A downriver view of McAlpin Locks and Dam. The Louisville and Portland Canal follows the left bank of the river, with the locks at the far end. The middle open reach leads to the hydroelectric plant. A 6,000-foot length of the dam follows a longitudinal course upriver from the powerplant. The former Indiana Chute is at the right



taken at Indiana Chute. A cofferdam was built across the chute in 1897 to discover the actual condition of the bedrock. Further excavation was then accomplished, to provide safer navigation, and traffic continued to use the chute at high water even after the 110- by 600-foot Lock 41 was completed in 1921.

Expansion of Capacity

In 1910 a movable weir dam was completed to provide for 9-foot navigation above the Falls to Madison, Ind., the site of the proposed Lock and Dam 40. Work on Lock 41—so designated in 1914—was begun in 1911, but because of the 1913 flood and a variety of untoward circumstances it was not brought to completion until 1921. While Lock 41 was under way, interest was developing in hydroelectric power generation at the Falls. Work on a new dam and powerhouse was begun in 1925. The new Dam 41, completed in 1927, was an L-shaped structure, 8 feet higher than the old dam and 8,652 feet long. It provided a 9-

foot channel depth from Louisville to the location where Markland Locks and Dam was later built, and made it unnecessary to construct the proposed Dam 40 at Madison. The new dam at the Falls was a movable weir structure with a navigable pass.

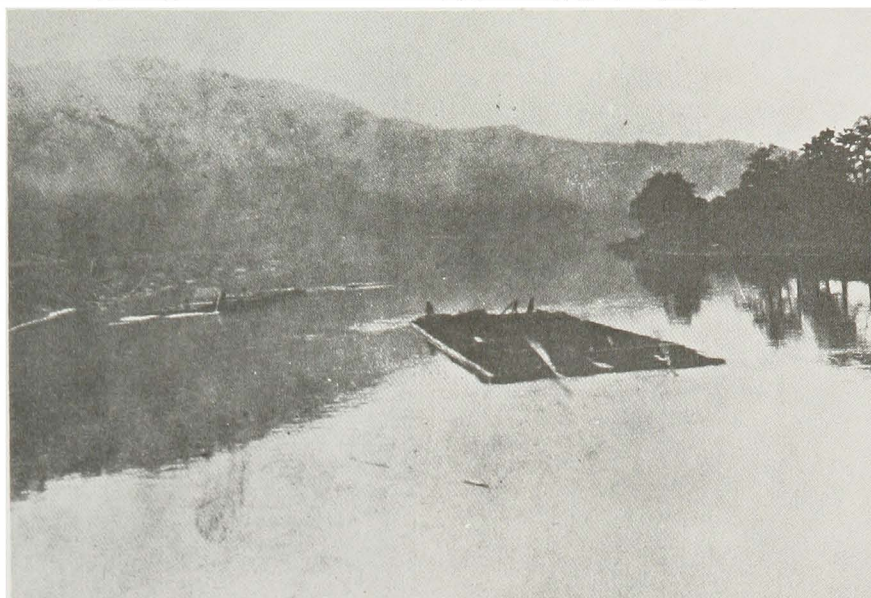
The old two-flight locks were replaced in 1930 by the still existing single-lift 56- by 360-foot lock.

A program of reconstruction and modernization was begun at Louisville in 1958. This included the building of a 110- by 1,200-foot lock, rehabilitation of the previously existing locks, and widening of the canal from 200 to 500 feet. The major portion of the dam was retained, but modification was made to a non-navigable, fixed weir, gate-controlled structure. The project name was changed to McAlpine Locks and Dam in 1960, honoring the District Engineer who served at Louisville in 1917-18.



An upriver view of McAlpine's three locks. On the right is Interstate 64, and in the middle distance at the right is downtown Louisville

Two pairs of coalboat bottoms, loaded with lath, shingles, etc., floating down the Allegheny. The photograph was probably taken in the late 1890s, but the scene suggests the appearance of coalboats of an earlier period, floating downstream without benefit of powered assistance. The bottoms were unloaded at Pittsburgh and towed to "siding yards" to be made into large coal barges



Development of Mass Movement

Mass movement as used here refers to large-scale shipment of commodities. The method has its application mainly to low-priced bulk commodities, notably coal, and on the inland waterways it implies the use of unpowered barges.

The mass movement principle in the modern era is aptly expressed in the title of *Big Load Afloat*, issued by American Waterways Operators, Inc., and the equipment used and the procedures employed are effectively described in that publication.

The first bulk-loaded barges simply floated with the current and were used in downriver movement only. Later, steamboats were used to guide, control, and propel the barges. Specially designed steam towboats were then used over a long period, and diesel towboats are now the source of power.

Early Bulk Shipments

Coal was shipped down the Ohio as early as 1793 by the Army Quartermaster Department to supply garrisons at forts on the frontier. Commercial shipments were begun within a quarter of a century, to supply river steamers, riverside industries, and steamships and sugar refineries at New Orleans. Coal from the Monongahela was first floated down the Ohio in 1814, and shipments from Pomeroy, Ohio, were begun in 1819.

The early shipments were loaded in roughly framed and planked coalboats, resembling flatboats, which were sold along with the coal at destination. The first coalboats were about 80 feet long by 18 feet wide and drew 40 inches. Later these boats were built to a length of 175 feet and a width of 26 feet, drawing 8 feet when

loaded with 24,000 bushels of coal. The boats were usually lashed together in pairs and floated downriver at high water stages, steered with long oars in the fashion of flatboats. Coalboating could be a dangerous business—seventy coalboats and seventeen crewmen were lost in an Ohio River storm of 1854, and coalboat losses averaged 10 percent annually. Profits, however, were high.

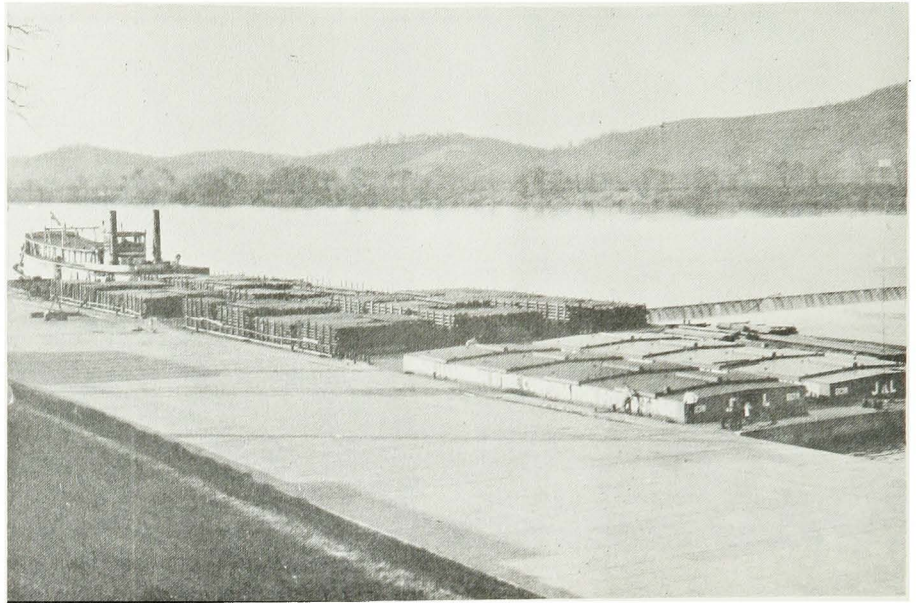
Trend toward Barge Towing

Milnor Roberts noted in 1866 that the one-way coalboats were gradually being replaced by steamboats towing fleets of coal barges downriver and returning the empty barges upriver for reuse.

The towing of keelboats behind and at the side of steamboats was begun almost from the start of the use of steamboats on the Ohio. The steamboat *Condor*, pushing keelboats lashed alongside from Pomeroy to Cincinnati in 1836, may have been the first to tow coal on the Ohio. Placing barges ahead of steamboats and pushing them became a common procedure during the 1840s. The first Ohio River towboat taking coal to New Orleans delivered 2,280 tons in four barges in 1854. But within a few years the size of the barges, the power of the steam towboats, and the number of barges in a tow had been greatly increased.

Milnor Roberts reported that, including shipments from Pittsburgh, Wheeling, the Kanawha, Pomeroy, the Big Sandy, Hanging Rock, and Ashland, 40 million bushels of coal (about 1.5 million tons) was shipped down the Ohio River in 1866 and that at least ninety steam towboats were engaged in the coal towing business. He saw the development of the barge towing

A Jones & Laughlin steel tow entering lockchamber at one of the former low-lift dams



system as the most important single trend in waterways commerce, and predicted that, though steamboat packets might survive in local passenger and freight trades, the bulk of commerce on the Ohio would ultimately be carried by means of towed barges.

Steam Towboat Technology

The essential features of advancing steam towboat design in the latter part of the 19th century were water-tube boilers, multiple-expansion engines, and screw propulsion. Charles Ward, a British engineer who settled in Charleston in 1871, was a key figure in introducing and improving the new technologies, and not alone for use on the western rivers: his company's steam generators competed in the Atlantic coast markets and were used by the U. S. Navy. Ward also

experimented with the tunnel design for propellers, but he did not apply the principle to the construction of towboats.

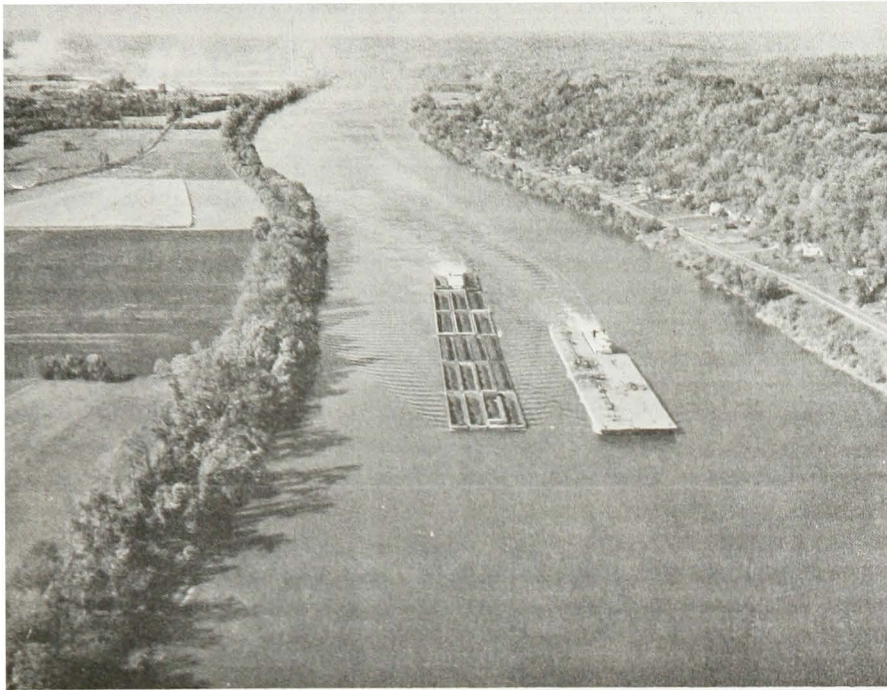
In 1903 Ward Engineering's *James Rumsey*, a twin-screw towboat, won at Charleston a definitive push-pull contest against the stern-wheel towboat *D. T. Lane*, "the pride of the Kanawha." Notwithstanding, paddle wheel towboats continued to be built for the western rivers well into the 20th century.

Development of the Diesel Towboat

The diesel engine as developed in Germany by Rudolf Diesel was patented by Diesel in 1892 and first successfully put to practical use in 1897. It is a compression-ignition engine using low-cost fuel oil, as distinguished from the spark-ignition engine using the



In horse-and-wagon days. The steam towboat A. C. Ingersoll, Jr. pushing a coal tow down the Ohio past Huntington (Greene Line Terminal). From the Sutphin Steamboat Photo Collection



Two upbound modern tows, passing Antiquity, Ohio, on the Gallipolis pool of the Ohio River. In the distance, on the West Virginia side of the river, are a steam-electric generating station and a nearby ferroalloys plant

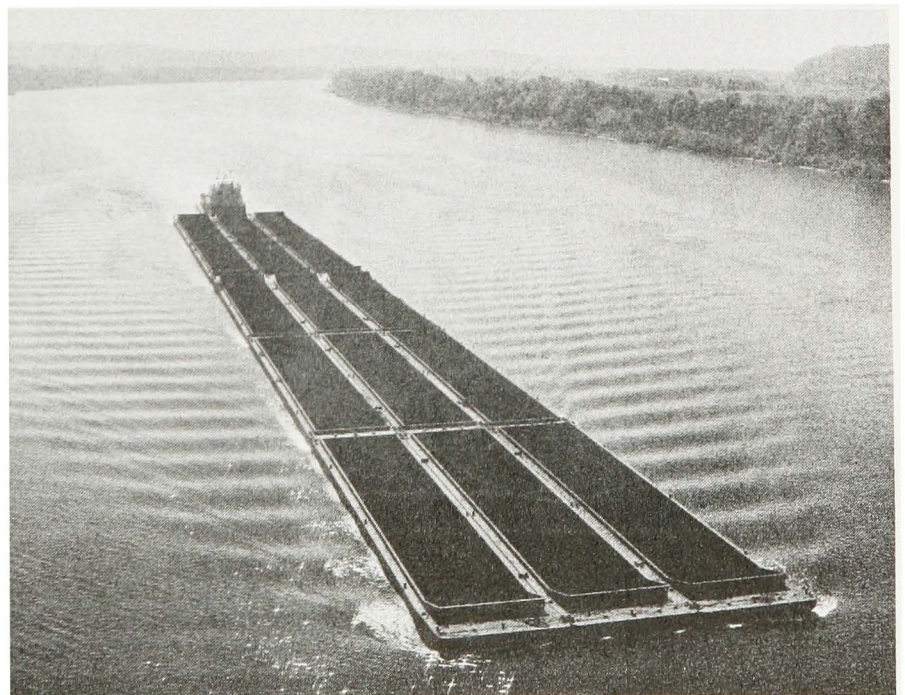
more highly refined gasoline, which came to be generally used in automobiles.

Except in naval work the use of the diesel engine was almost unknown in the United States until about 1915. Development of the diesel during the 1920s was, however, phenomenal. The reasons for this were well stated by W. S. Covington in an article in the October 1929 Ohio River Edition of *National Waterways*:

The modern marine Diesel engine has a sturdiness and a dependability even exceeding the records

made by the old gasoline and oil engines In addition the Diesel of today has a thermal efficiency nearly forty percent greater than the most modern steam condensing turbine plant. With such economy combined with the elimination of boiler room crew, small space required for engine room and fuel, great cruising radius, no standby losses and ease of starting it is easy to understand how the Diesel has assumed first place in the power plants of river vessels of under 800 H. P. laid down during the past ten years.

The towboat A. N. Prentice with a fifteen-barge coal tow on the Ohio River near Louisville



Regardless of the type of drive, whether sternwheel, propeller or electric, the advantages of the Diesel are equally applicable.

The extent to which the diesel engine was coming into use in Ohio River towing is suggested in the Corps handbook on *The Ohio River: 1934*. Ten river points were listed where diesel fuel oil could be obtained: Pittsburgh, Steubenville, Wheeling, Huntington, Cincinnati, Louisville, Evansville, Paducah, Metropolis, and Cairo. Sixteen points were named where coal could be obtained.

Steam Dwindles, Efficiency Increases

When the canalization of the Ohio River was ac-

complished in 1929, many steamboats were still in use and the towboats were typically steam-powered. The use of steamboats quickly dwindled during the Depression, however, and by the mid-40s fully half the towboats were diesel. By the mid-50s the changeover to diesels was almost complete. The power and efficiency of the towboats, meanwhile, steadily increased, and this improvement has continued.

Data on the sizes of present-day towboats and barges and the capacities of tows are included in Part II of this booklet: *Ohio Navigation as It Is Today*.

An accompanying table presenting figures on the tonnages and ton-miles of waterborne commerce on the Ohio River provides a measure of the remarkable growth of the mass movement on the Ohio since the period of World War I.

Waterborne Commerce on the Ohio River 1915-1977

(At five-year intervals, 1915-75)

Year	T O N N A G E (In thousands)							Ton-Miles (In millions)
	Coal and Coke	Petroleum Products	Aggregates	Chemicals	Iron and Steel	All Other	Total	
1915.....	4,546	4	2,024		26	747	7,346	1,095
1920.....	6,651	46	1,239		367	1,078	9,382	1,184
1925.....	6,925	271	7,406		580	555	15,737	826
1930.....	9,769	482	9,526		1,481	1,079	22,337	1,474
1935.....	12,812	1,564	4,144		1,136	1,321	20,977	2,254
1940.....	16,608	3,997	5,545		2,114	1,285	29,549	3,853
1945.....	18,458	8,370	4,261		1,139	1,640	33,868	6,065
1950.....	23,860	11,733	8,12		2,310	2,442	48,598	8,800
1955.....	37,963	14,517	9,958	1,647	4,369	3,007	71,461	14,901
1960.....	39,904	16,337	10,137	3,355	3,685	6,060	79,478	17,704
1965.....	46,606	20,508	14,209	5,961	3,439	12,451	103,174	23,275
1970.....	59,001	25,312	17,240	10,583	4,382	13,067	129,585	30,254
1975.....	73,301	19,620	16,491	9,069	3,896	17,678	140,058	32,320
1977.....	81,593	19,255	17,963	9,311	4,266	19,009	151,402	37,476

Chemicals are included in "All Other" in the years 1915 to 1950.

Davis Island: The Beginning of Canalization

Canalization of the Ohio River got off to a slow start, partly because of the dimensions of the engineering problem to be dealt with, partly because of the objections of the riverusers themselves, many of whom thought of dams as hindrances to navigation.

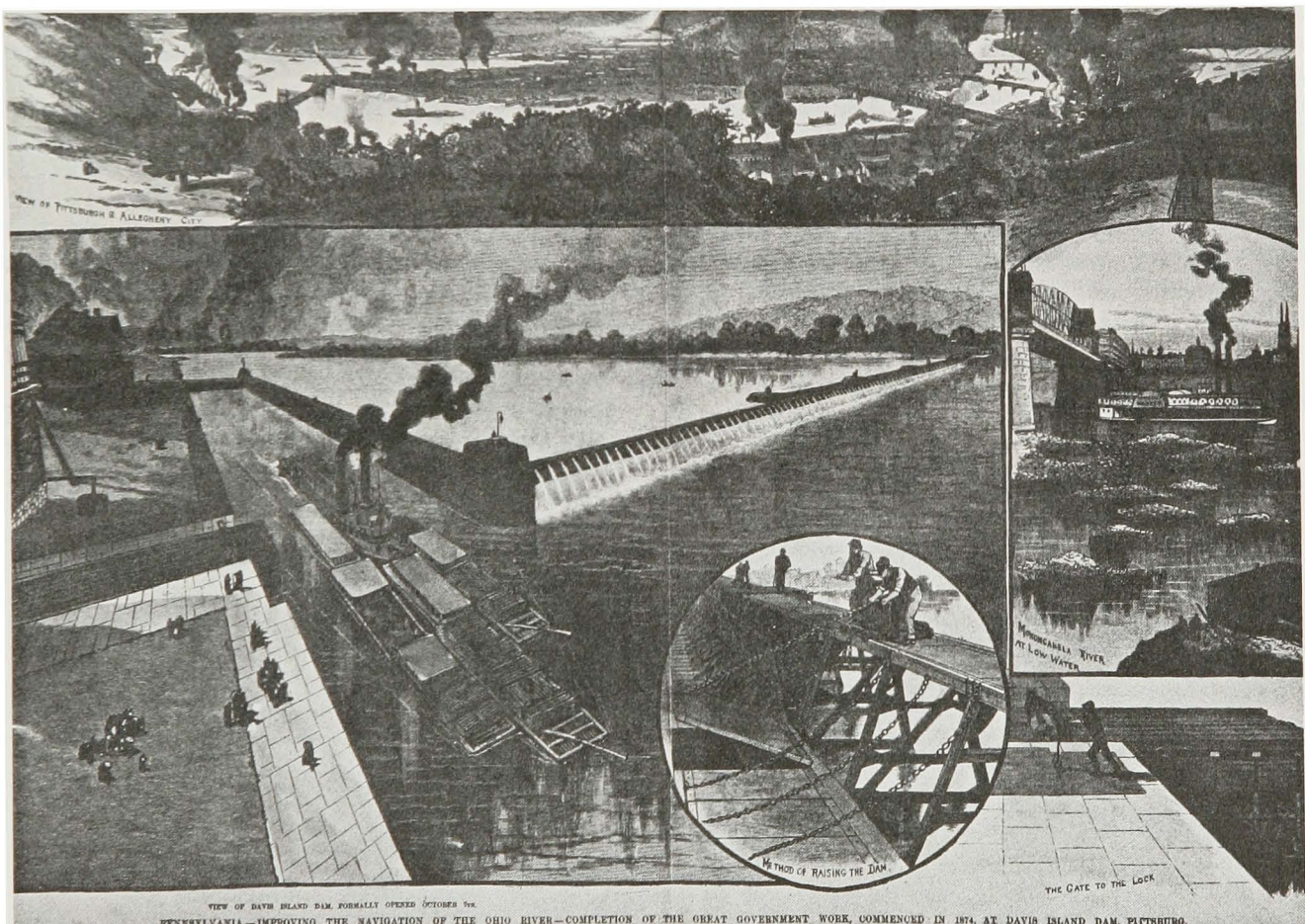
It became evident eventually, however, that to provide for the accommodation of coal fleets, particularly in the upper course of the Ohio, it would be

advisable to provide adequate depth by the use of navigable pools created by dams, the dams to be equipped with locks by which vessels could be raised or lowered from one pool to the next.

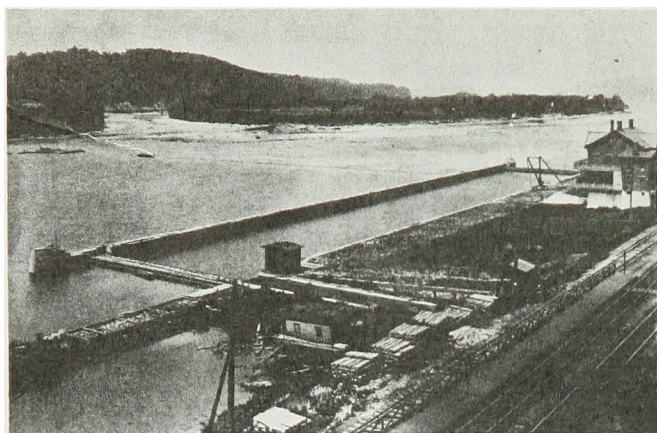
As early as 1835, Lieutenant George Dutton had expressed the view that only the construction of locks and dams would adequately improve the river for year-round use. The idea was long neglected, however, until it was revived by W. Milnor Roberts in 1870.

In 1874 Major W. E. Merrill recommended the construction of thirteen locks and movable dams between Pittsburgh and Wheeling. He advised that locks were essential in any plan for improving the upper Ohio to secure a 6-foot navigable depth. The following year he expressed himself in favor of the use of movable dams throughout the river, qualifying his recommendation as to applicability below the Falls.

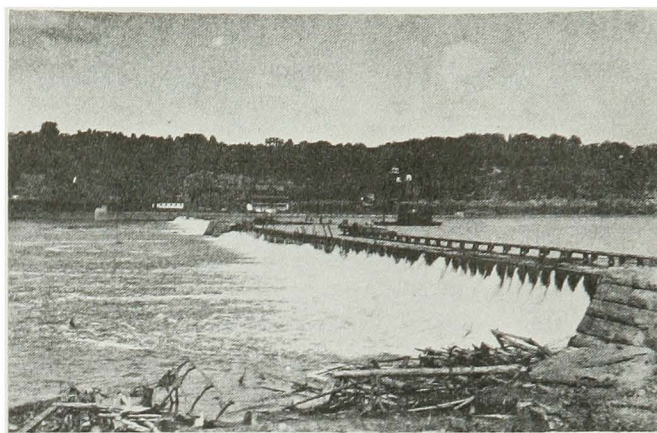
An artist's montage of 1885, depicting "Completion of the great Government work, commenced in 1874." From the Collection of the Pittsburgh History and Landmarks Foundation



Main picture: An upriver view of Davis Island Lock and (main) Dam, with a downbound tow leaving the lock. The inset shows the method of raising the dam. At lower right: One of the lock's rolling gates is being retracted. Above: A view of Pittsburgh and Allegheny city. Right center: "Monongahela River at low water"



Davis Island Lock in 1890. In this downriver view the dam is barely visible



An upriver view of the main dam from the Davis Island end

Davis Island: A Test Undertaking

In the River and Harbor Act of 1875, Congress appropriated \$100,000 toward building a movable dam (or a dam with adjustable gates) at Davis Island (4.7 miles below Pittsburgh) to test the best method of improving the Ohio River and its tributaries. Work on the dam, known later as Dam 1 of the numbered system of dams on the Ohio, was begun in 1877 and the structure was opened for traffic on 7 October 1885.

The Davis Island Dam was undertaken originally for the purpose of providing a pool at Pittsburgh below the Monongahela River navigation system which would permit the assembling of coalboats and the formation of tows of practicable size ready for the downstream run when "a coalboat rise" occurred on the Ohio.

Why a Movable Dam?

The idea of making the Davis Island Dam a movable

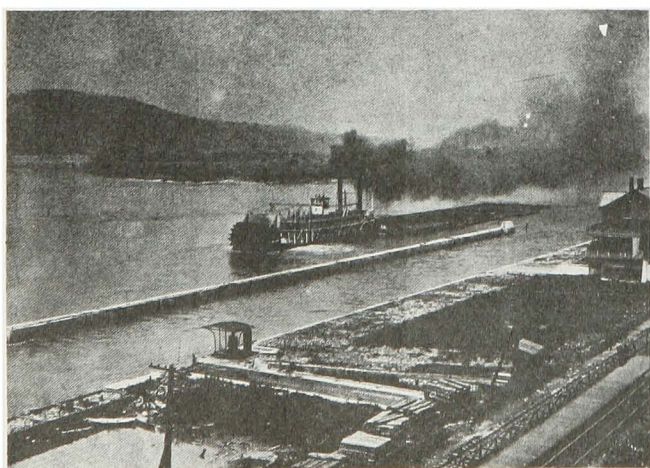
one, that could be raised to maintain a harbor pool during dry periods and lowered during high water to permit the coalboat fleets to pass without lockage, was adopted to meet the needs of the coalboat operators.

To determine the method by which these purposes might best be accomplished, study was made of methods employed in several European countries, and model studies were also made of methods proposed by Americans.

Selection of Chanoine Wickets

The outcome of the studies was the selection of a movable wicket dam invented in 1852 by Chief Jacques Chanoine of the French Corps of Engineers and which had come into use on the Seine and other French rivers. These wickets, it was decided, could be adapted to meet the problems on the Ohio.

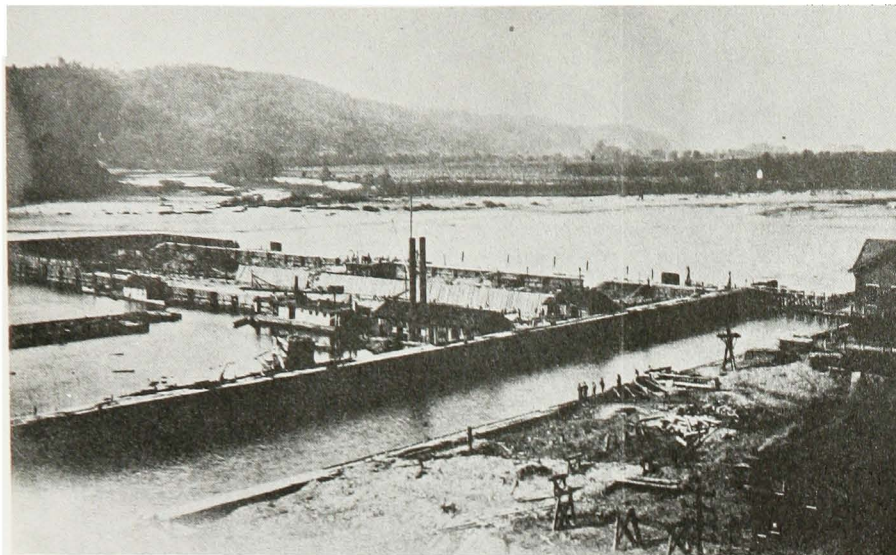
In briefest terms, chanoine wickets consisted of timbers bolted together that resembled huge wooden ironing boards. At high water these lay flat against



A high-water scene in 1890 with a coal tow bypassing the lock



Lockage of a coal tow, 14 May 1910. Pittsburgh is in the distance



Construction in progress on navigable pass section of Davis Island Dam, 1884. Captain Frederick Way, Jr. Photo

masonry foundations and left an open channel for navigation; at low water they could be raised on end to form a dam.

Design and Operation of Dam

The Davis Island Dam was 1,223 feet in length. This included a chanoine wicket navigable pass of 559 feet and three chanoine weir sections—used to regulate pool levels—the four sections separated by three masonry piers.

Because of heavy ice conditions on the Ohio it was deemed best to depart from the French method of raising and lowering the wickets of the navigable pass by means of a service bridge and, instead, to use a maneuverboat.

A service bridge was used for operating the chanoine wickets of the weirs at Davis Island. However, because the bridge was damaged by barges on several occasions and was practically destroyed by the debris carried on the crest of the Johnstown Flood in 1889, this feature was eliminated in the building of later dams, maneuverboats being used for the raising and lowering of all the wickets, whether in the navigable pass or the weir sections. The debris problem also led to the installation in 1889 at Davis Island of a drift gap—closable by so-called beartrap gates—through which floating logs and other debris could be flushed.

Raising and lowering of the wickets was required ordinarily only at infrequent intervals, depending upon

the occurrence of low water or flood. The operation was arduous in any event, however, and especially so under ice conditions. It seems hardly a typographical error to see the structures referred to as wicked dams.

Construction of Lock

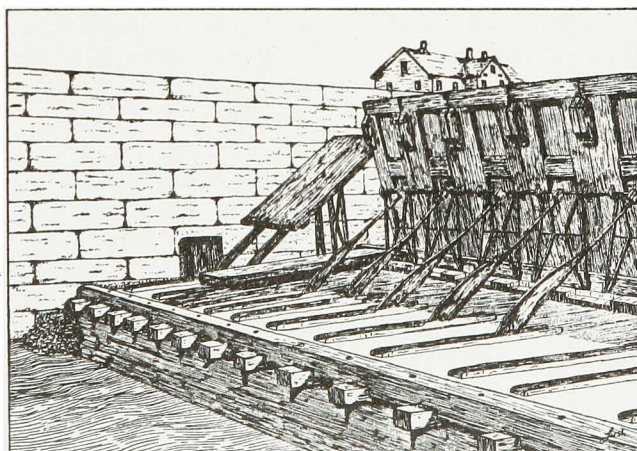
The lock at Davis Island was 110 feet wide by 600 feet long—designed, again, to meet the needs of the coalboat fleets—and these dimensions became standard in the canalization of the entire river.

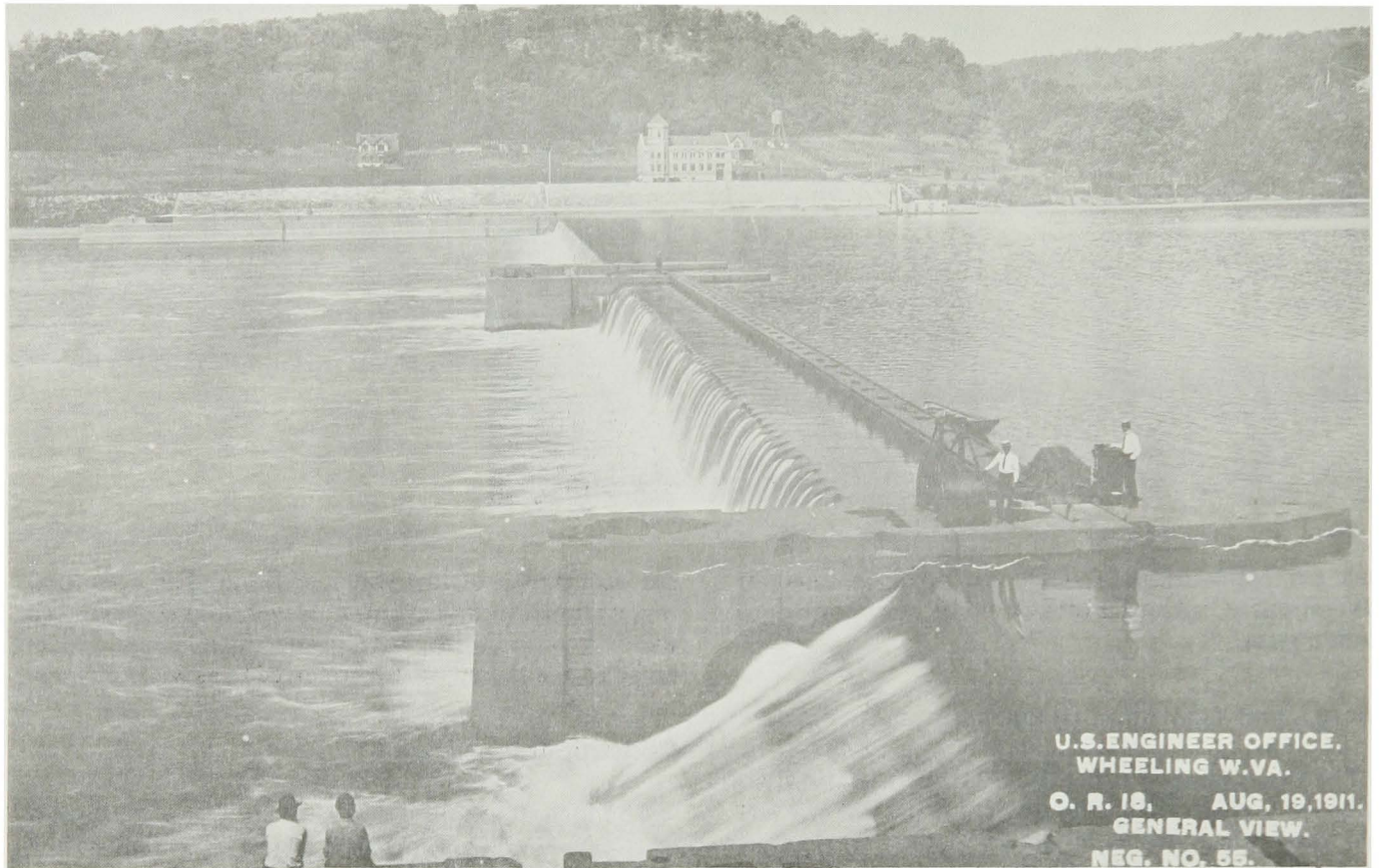
Rolling gates mounted on wheels were used to close the lockchamber, as means of building swinging miter gates to close a lock of 110-foot width had not been devised. When open, the roller gate was housed in a recess in the landward lockwall.

Back Channel Dam

The back channel of the Ohio, between Davis Island and the south shore, was closed by a nonnavigable stone-filled timber-crib dam.

Chanoine wickets in the dry, during construction of Davis Island Dam. The drawing shows the back or downriver side of the wickets





Lock and Dam 18, at River Mile 179.9, four miles above Parkersburg, was opened for use in 1910. The segments of the structure include: (1) near at hand, a 61-foot beartrap, (2) a 300-foot chanoine wicket weir, (3) a 73.5-foot beartrap, (4) a 700-foot chanoine wicket navigable pass, and (5) the 110- by 600-foot lock. The lift at normal pool was 6.2 feet

Canalization Continued, and Completed

A board of three Engineer officers appointed pursuant to the River and Harbor Act of 1881 recommended the construction of four dams below Davis Island. Appropriations for Locks 2 to 6 inclusive were made by various River and Harbor Acts beginning in 1890.

Lock and Dam 2 was built in the 1898-1906 period, at Mile 9.0, and Dam 3 in the 1899-1907 period at Mile 10.9. Lock and Dam structures 4, 5, and 6 were built in the 1892-1908 period at River Miles 18.6, 24.1, and 29.3, respectively.

The River and Harbor Act of 1896 authorized a survey from Pittsburgh to Marietta to determine the number of movable dams needed to provide a 6-foot navigable depth. The report (House Document 122, 55th Congress, 3rd session, 1899) proposed a system of eighteen locks and dams between the points indicated.

The River and Harbor Act of 1899 provided for a survey between Marietta and the mouth of the Miami River, below Cincinnati, with a view to providing a 6-foot navigable depth by means of movable dams.

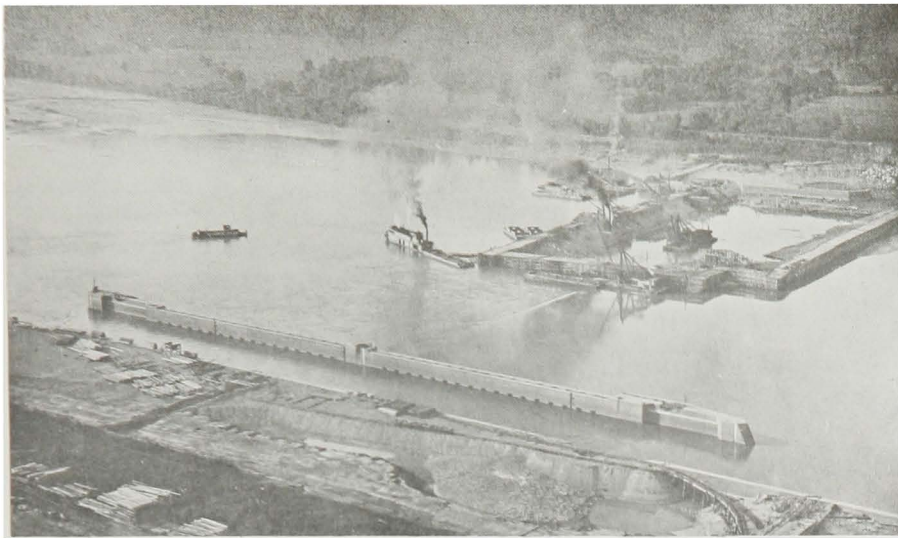
These were given numberings consecutive with the numbers already assigned.

Beginning of 9-Foot Project Depth

A board of Engineer officers designated under the River and Harbor Act of 1902 advised that a navigable depth of 9 feet be provided for the upper portion of the river, and the River and Harbor Act of 1905 appropriated funds for securing a 9-foot stage in the pools made by Dams 2, 3, 4, 5, and 6 by a modification of those locks and dams.

Findings of the Lockwood Board

House Document 492 (60th Congress, 1st session), dated January 1908, embodies the results of an examination of the Ohio River by a special board of engineers, made in compliance with the provisions of



Construction of Lock and Dam 33, three miles above Maysville, 1 August 1918. The original photograph is labeled: "General view from tree on hill."

The picture below shows the completed lock and dam. The date is not indicated, but tows already exceeded the length of the lock, necessitating double lockages

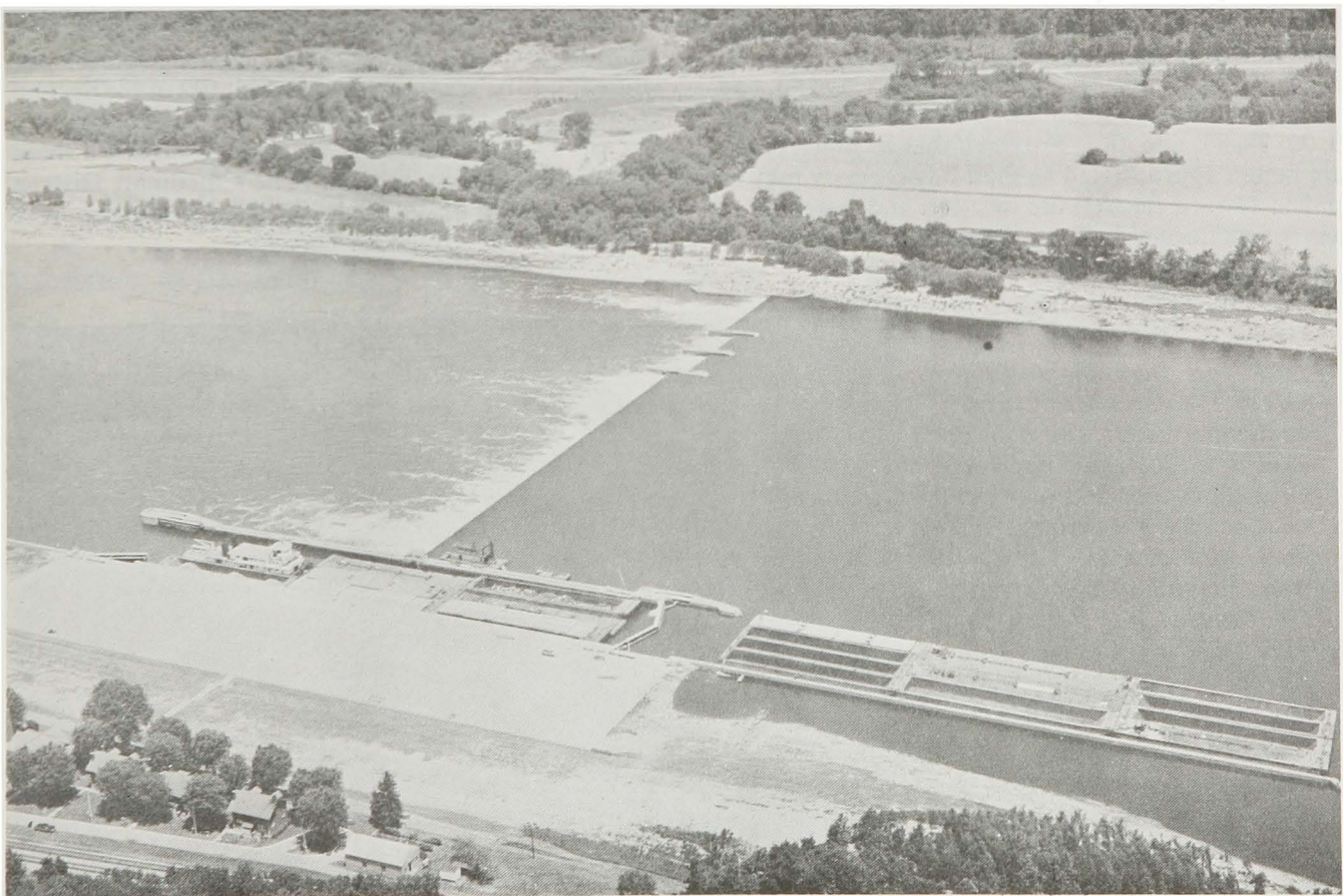
the River and Harbor Act of 3 March 1905 for the purpose of developing "necessary data with reference to the canalization of the river, and the approximate location and number of locks and dams in such river, with a view both to a depth of six feet and nine feet; . . ."

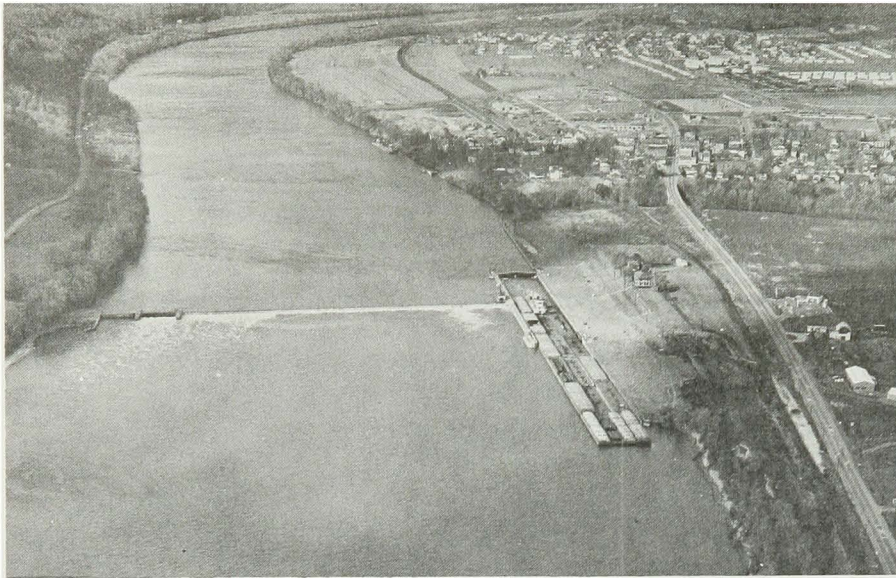
The special board (designated the Lockwood Board, for its chairman), in its report under date of 15 December 1906, recommended a 9-foot project for the Ohio River, involving fifty-four locks and dams. This report was referred to the Board of Engineers for

Rivers and Harbors for review, and that Board, after making a personal inspection of the river and conducting a public hearing, prepared its own report, dated 18 October 1907, supporting "without qualification" the plan of improvement proposed by the special board.

Nine-Foot Depth Authorized for Entire River

Provision for a minimum navigable depth of 9 feet





Lock and Dam 22, at Ravenswood, River Mile 220.9, opened for use in 1918. The photograph shows the need of double lockages to handle the longer tows which eventually came into use. The dam included a 600-foot navigable pass, a 240-foot bebout weir, a 115-foot beartrap, an 8-foot sluice, an 81-foot fixed weir, and a 50-foot abutment. The lift at normal pool was 7.8 feet

for the entire Ohio River was initiated in the River and Harbor Act of 1910. The act called for continuing improvement of the river "with a view to securing a navigable depth of nine feet in accordance with the report submitted in House Document Numbered Four hundred and ninety-two, Sixtieth Congress, first session, or such modification thereof as in the discretion of the Secretary of War may be advisable, and with a view to the completion of such improvement within a period of twelve years."

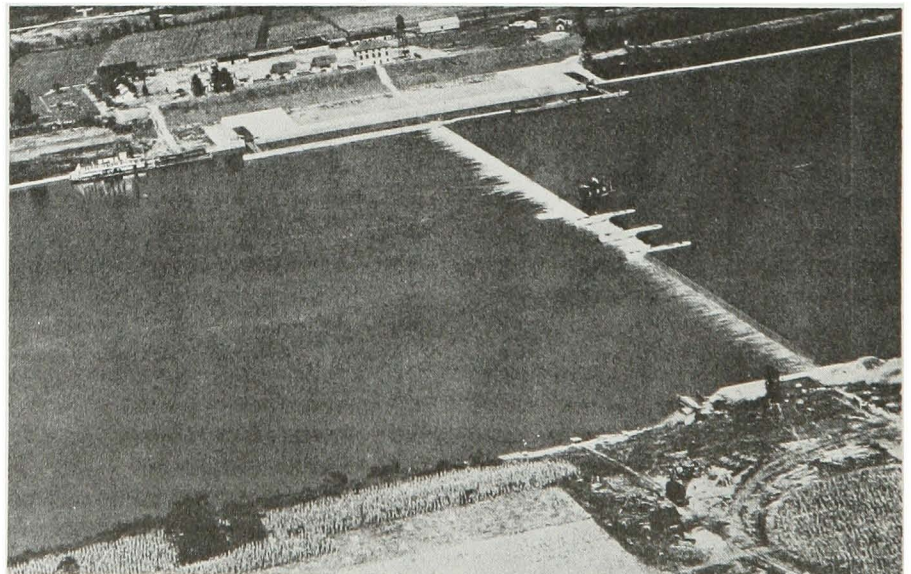
The sum of \$1,150,000 was appropriated, which amount was to be applied to the purchase of sites for eighteen locks and dams, numbered 9, 10, 12, 14, 15, 16, 17, 20, 21, 22, 23, 24, 25, 27, 28, 29, 41, and 48, and toward the construction of Lock and Dams 7, 9, 10, 12, 19, 20, 29, 41, and 48: "Provided that so much of the sum herein appropriated as shall be necessary may be applied toward the definite location and purchase of sites for additional locks and dams on said river: ..."

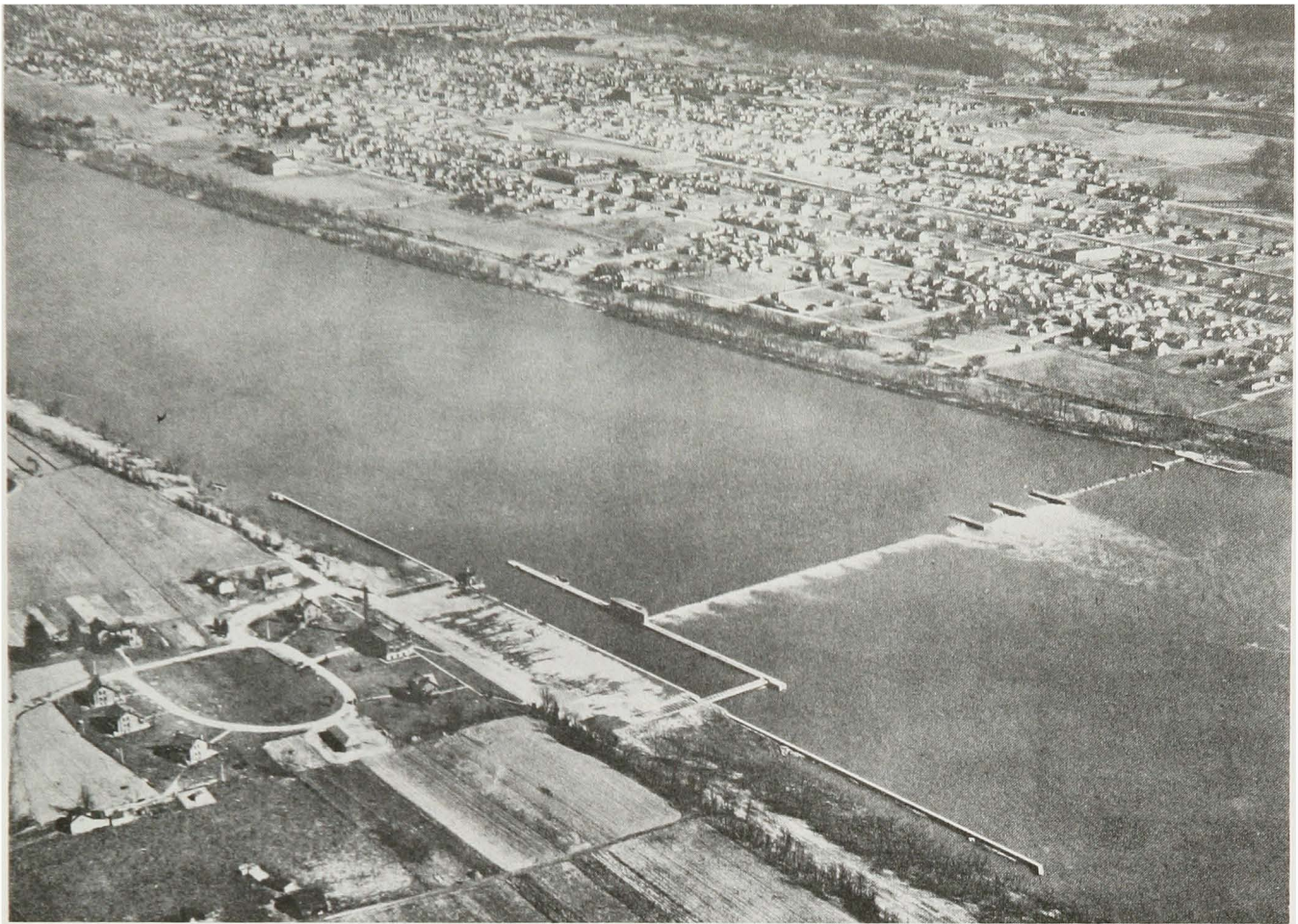
Assignment of Projects to Corps Districts

As the 9-foot slackwater program for Ohio River navigation got under way in 1910, the projects were divided among four Engineer Districts: Pittsburgh had Dams 1 to 10 (Pittsburgh to Steubenville); Wheeling had Dams 11 to 28 (Steubenville to Huntington); Cincinnati had Dams 29 to 40 (Huntington to Madison); and Louisville had Dams 41 to 54 (Madison to the Mississippi River).

In 1922, as active construction ended on the upper Ohio, the District office at Wheeling was moved to Huntington, responsibility for Lock and Dam 11 was shifted to Pittsburgh, the responsibilities of the Second Cincinnati District were transferred to Huntington, and the First Cincinnati District was assigned a share of the canalization project. (The Cincinnati District came to an end in 1947, when its responsibilities were assigned to the Louisville District.)

Lock and Dam 34, at Chilo, Ohio, River Mile 434.1, September 1925. The dam included a 700-foot navigable pass, a 100-foot chanoine weir, two adjoining beartraps (220 feet), and a 535.4-foot fixed weir. The rolling lock gates and the recesses into which they were rolled may be plainly seen. The lift of the structure at normal pool was 5.6 feet





Lock and Dam 28, at Huntington, River Mile 311.6, 29 February 1932. The structure was opened for use in 1915. The dam included a 700-foot navigable pass, two beartraps (220 feet), a 296-foot chanoine weir, a 70-foot fixed weir, and a 44-foot abutment. The lift at normal pool was 7.1 feet. In the photograph the lower rolling lock gate is closed, the upper gate is open

Completion of Canalization

Canalization of the Ohio was not accomplished in twelve years, as contemplated in the Act of 1910. But in the course of some nineteen years, supported by many congressional appropriations, a 9-foot navigable depth had been provided for the entire 981 miles.

The system had involved the construction of fifty-one movable (wicket) dams, each with a 110- by 600-foot lockchamber. (Of the fifty-four structures originally contemplated, the structures numbered 40, 42, and 54 were eliminated through modification of other projects.) Each movable dam had a navigable pass in which the wickets could be lowered to permit open-channel operation during periods of high water.

Replacement of Navigable with Nonnavigable Dams

An Ohio River board in its report on "Reexamination of Ohio River" dated 29 April 1916, embodied in

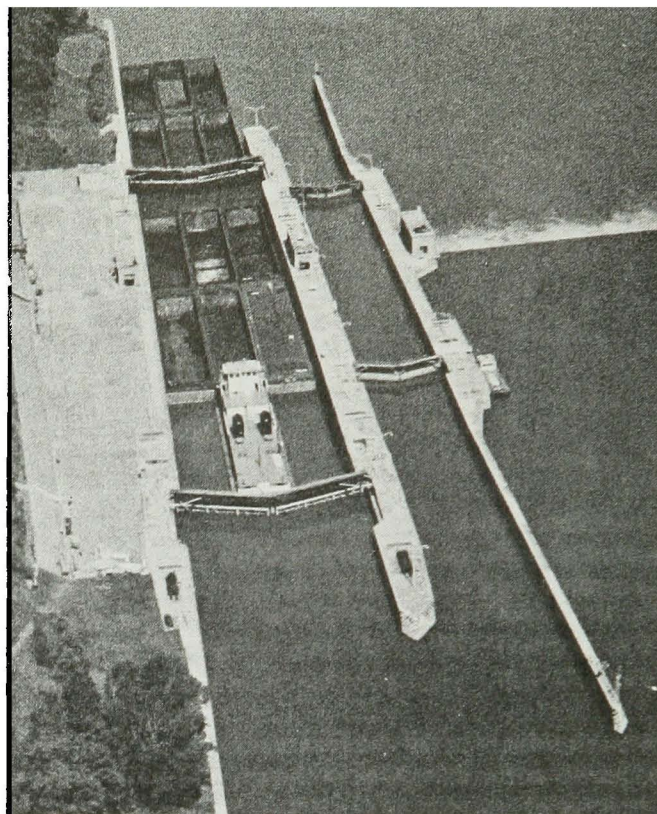
House Document No. 1695 (1916), included these recommendations (supported by the Board of Engineers for Rivers and Harbors and the Chief of Engineers):

"(a) That the Secretary of War be given authority, if the same is not already possessed, to cause fixed dams to be built in the Ohio River wherever such fixed dams would be more advantageous than movable dams, and that such authority be secured by the first bill in Congress to which its enactment would be germane.

"(b) That a fixed dam at or near Emsworth, Pa., be built at an early date to take the place of existing Dams 1 and 2."

The River and Harbor Act of 1918 appropriated \$5,000,000 for the continuing improvement of the Ohio River by the construction of locks and dams with a view to securing a navigable depth of 9 feet: "Provided, That the Secretary of War is hereby authorized to modify the project for the improvement of the Ohio River in accordance with the report submitted in House Document Numbered Sixteen hundred and

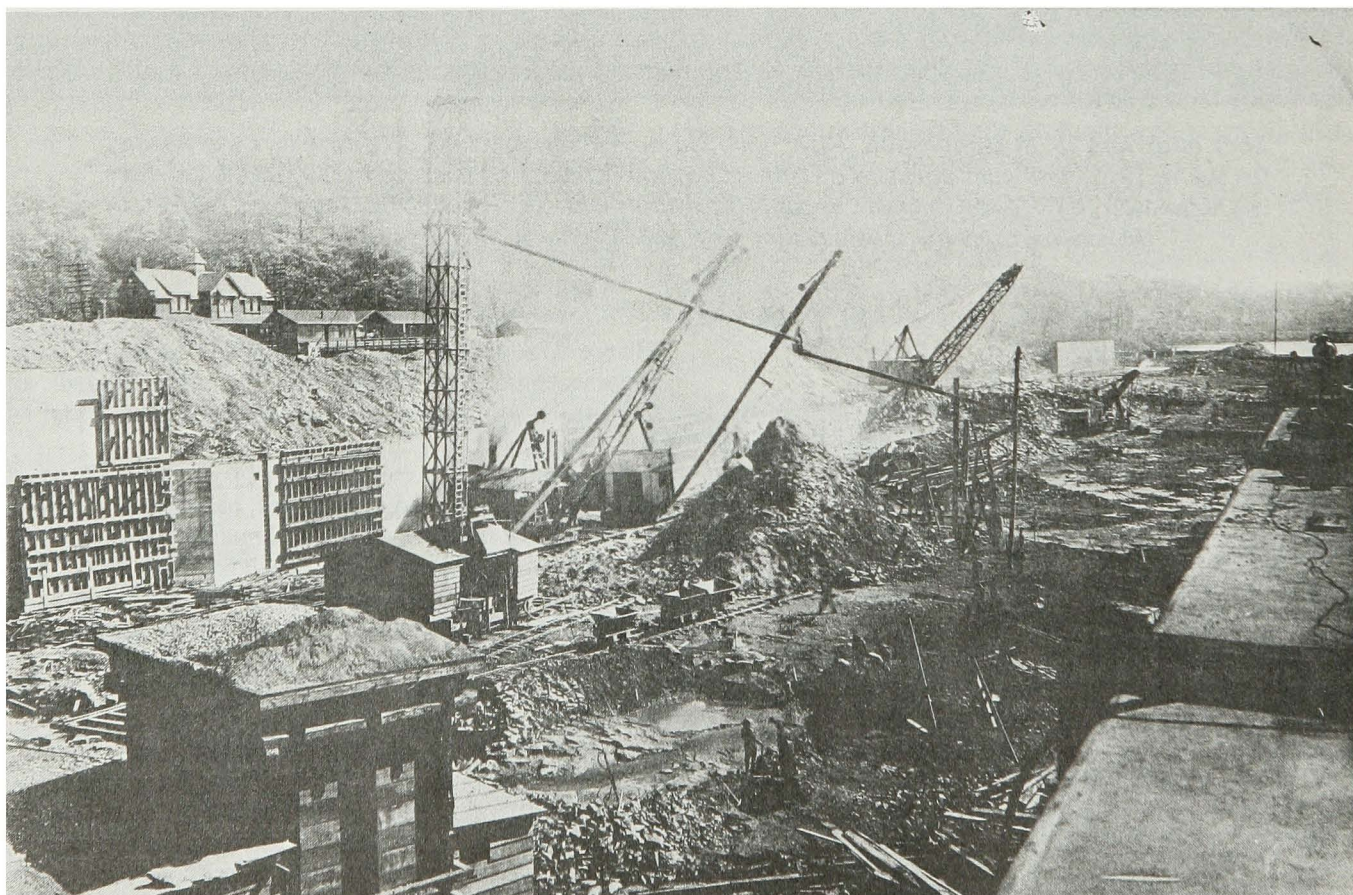
Dashields Locks and Dam, River Mile 13.3, built between 1927 and 1929 to replace Dam 3 (built between 1899 and 1907). The lift is 17.5 feet. The main lock is 110 feet wide and 600 feet long, the auxiliary lock 56 feet by 360



ninety-five, Sixty-fourth Congress, second session: . .

Lock and Dams 1 and 2, the structures next below Pittsburgh, were replaced in 1921 by the fixed concrete (nonnavigable) Emsworth Locks and Dams at Mile 6.2. In 1929, Dashields Locks and Dam, similar in method of construction to Emsworth, was placed in operation at Mile 13.3, taking the place of Lock and Dam 3.

Thus, in 1929, when the 9-foot channel on the Ohio was completed, fifty lock and dam structures were in operation, of which all but two had a navigable pass.



Work in progress on the main lockchamber at Emsworth Locks, River Mile 6.2, 2 October 1920. The Emsworth structures replaced Lock and Dams 1 (built 1877-85) and 2 (1898-1906)



A wicket dam on the Ohio River on 28 December 1935. Maneuverboats normally carried on their operations on the upstream side of the dam. Here, ice conditions made it necessary to work from the downriver side

Emsworth Locks and Dams

Emsworth Locks and Dams stands at the head of the Ohio River main stem navigation system, 6.2 miles below the Point at Pittsburgh, where the Allegheny and the Monongahela join to form the Ohio. The site selected for Emsworth was at five-mile-long Neville Island, where the existence of channels on either side of the island necessitated the building of dams on both channels.

At Emsworth the use of movable wooden wickets was definitely abandoned for the first time on the Ohio River, and nonnavigable concrete dams were adopted instead. Because traffic could not be passed through the dam, should a lock be closed under emergency conditions, two locks were built, one with standard 110- by 600-foot dimensions and the other with standard 56 by 360 Monongahela dimensions, both with a 13-foot lift. Double locks permitted lock repair without shutting down navigation, lockage of two tows could be carried out at the same time, and the smaller lock could be used during droughts to conserve water.

The locks were opened for navigation on 1 September 1921, the project providing both the first nonnavigable dam and the first double locks on the Ohio.

As the Davis Island (No. 1) Lock and Dam, with its navigable pass, was deemed experimental, so was Emsworth experimental. Plans for additional concrete dams were held up until rivermen and Pittsburghers became convinced that the dam at Emsworth presented no threat to their business or their property.

Further detail on Emsworth is given in a section following, dealing with In-Between projects.

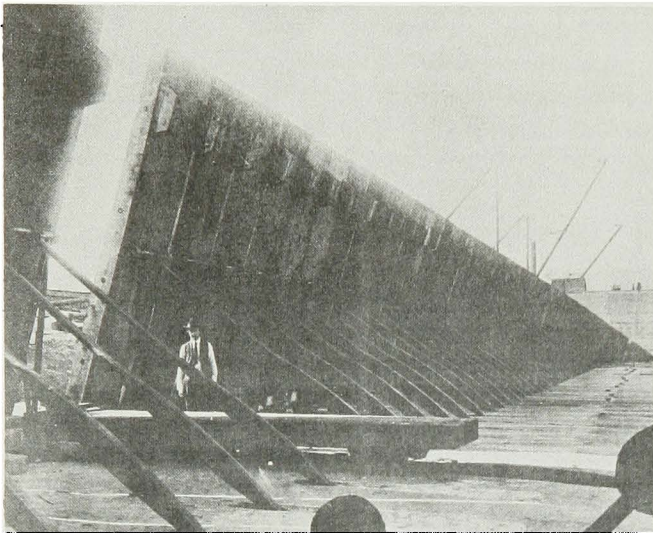
Dashields Locks and Dam

Construction of Dashields Locks and Dam, at Deadman's Island, was approved by the Chief of Engineers in 1926, under authority of the River and Harbor Act of 1909. It was named for pioneer David A. Shields of nearby Shields Station.

The dam is 1,585 feet long and provides a normal upper pool elevation of 692.0 feet above sea level, extending 7.1 miles to Emsworth Dam. A significant feature of the new structure was that it served to submerge permanently a reach of rapids which became exposed and hazardous when the wickets of Dam 3 were down.

An innovation at Dashields was the use of cast steel armoring for exposed vertical corners of lockwalls, which thereafter become standard on all inland waterways.

Operation of Navigable Dams



A wicket dam during course of construction

Low-lift navigable dams were adopted for use in the initial canalization of the Ohio River for two purposes: (1) to provide an adequate navigable depth upstream from the dam at periods of low water, and (2) to permit navigation over the dam when the water was high.

The width of the navigable pass at the different movable dams varied from 600 to 1,248 feet. The pass provided a channel for open-river navigation when the wickets were down. When the wickets were up they formed a part of the dam.

Construction of Wickets

The wickets were 3.75 feet in width and from 15 to 20 feet in length, varying at the different dams. They were arranged to allow open spaces of 3 inches between adjoining wickets, which spaces could be closed by the placing of small square timbers called needles. The wicket itself was a heavy timber shutter pivoted to a frame called a horse, which in turn was pivoted to the foundation of the pass. Attached to the horse was a long, heavy forging called a prop, the lower end of which rested in a groove formed of cast iron and provided with a shoulder or step.

How Wickets Worked

When not in use the wicket lay flat on the pass foundation at such a depth below the water as to offer no obstruction to navigation.

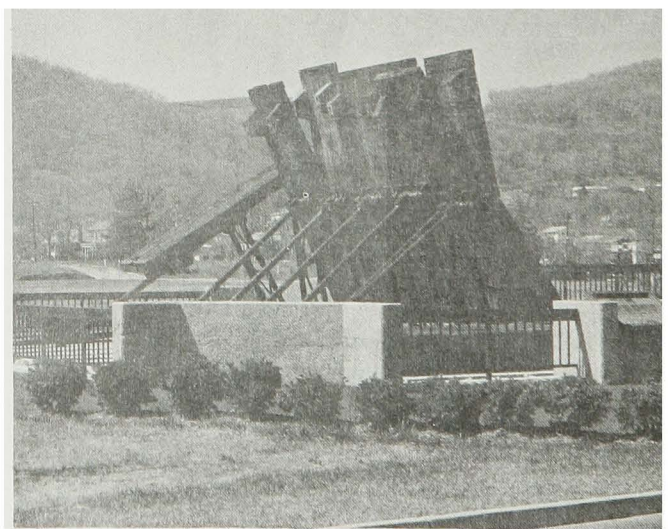
When the wickets were to be raised to close the navigable pass, they were grappled for and raised one at a time by means of devices on a maneuver boat. As the wicket was pulled upward and forward (that is, upstream) the prop attached to the horse followed in its

cast-iron groove until its lower end dropped into place against the shoulder or step. The prop, being set in place, the wicket was tipped from a nearly horizontal to a nearly vertical position, with its lower edge resting against the sill of the pass and its middle braced in position by the prop.

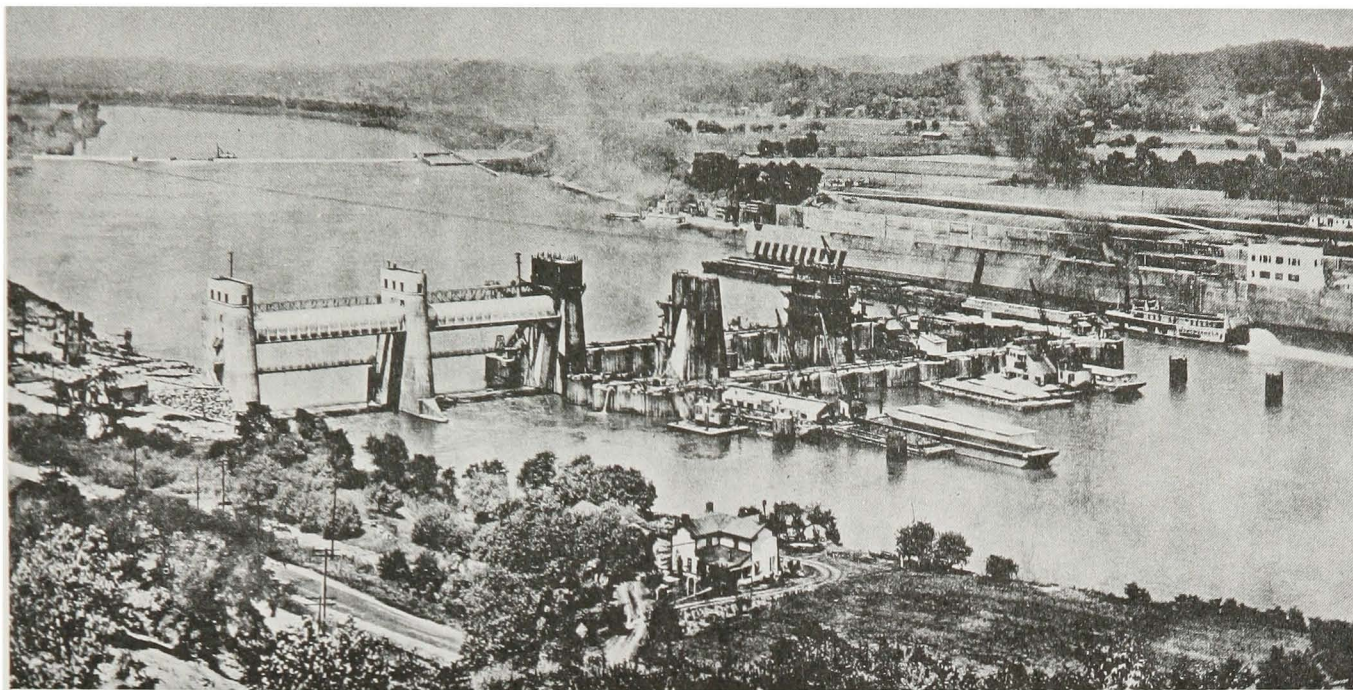
Other Elements of Dams

The function of beartraps and other weirs was to regulate upstream pool levels within certain limits. The beartrap weirs, convertible into sluices to allow the passage of accumulated debris, were structures of iron, steel, and wood, in two leaves, hinged at their outer ends. The lower leaf of each beartrap was a hollow structure like a pontoon, into which air could be forced to increase its buoyancy. By the combined effect of this buoyancy and the pressure due to hydraulic head caused by raising the wickets in the navigable pass, the lower leaf rose into position, raising the upper leaf. When the beartrap was up it formed an A-like structure resembling the deadfall used in trapping bears. The beartraps were usually two in number and were operated quickly and independently of each other to form sluices for debris. They also permitted the flow of water to be regulated with nicety.

Most of the Ohio River dams also had a section of chanoine weir which was a repetition of the navigable pass, with its sill placed at a higher level, and having, in consequence, wickets of shorter length. This section was used to adjust the pool level at flows where the navigable pass was up and there was danger of the wickets being overtopped.



A wicket dam display at Hannibal, installed to promote a better understanding of the earlier period of canalization



Gallipolis Locks and Dam while under construction. Seven-tenths of a mile upstream may be seen Lock and Dam 26, one of six low-lift lock and dam structures replaced by Gallipolis

In-Between Projects

During the 1930s, following completion of the 9-foot canalization of the Ohio River (1929) and before the beginning of the Modernization Program (1953), two navigation projects were begun and completed on the Ohio: the high-lift Montgomery and Gallipolis locks and dams. Both of these projects represented an advance over the original low-lift navigable dams, but both fell short of the modernization concept.

Other work relating to Ohio River navigation taking place in the In-Between period included (1) completion of a replacement lock at Locks and Dam 41, at Louisville, (2) construction of Tygart Lake, on Tygart Valley River, and (3) the raising of the level of Emsworth Dams, all of which projects were accomplished before 1940. No new navigation projects were undertaken during World War II.

Montgomery Locks and Dam

The building of Montgomery Locks and Dam, located at River Mile 31.7, was begun in 1932 and the structure was opened for use in June 1936. It replaced three of the original numbered lock and dam structures: 4 (built 1898-1908), 5 (1898-1907), and 6 (1892-1904).

The dam, 1,379 feet in length, includes ten 100-foot vertical-lift gated spillway sections. The main lock has usable dimensions of 110 by 600 feet and the auxiliary

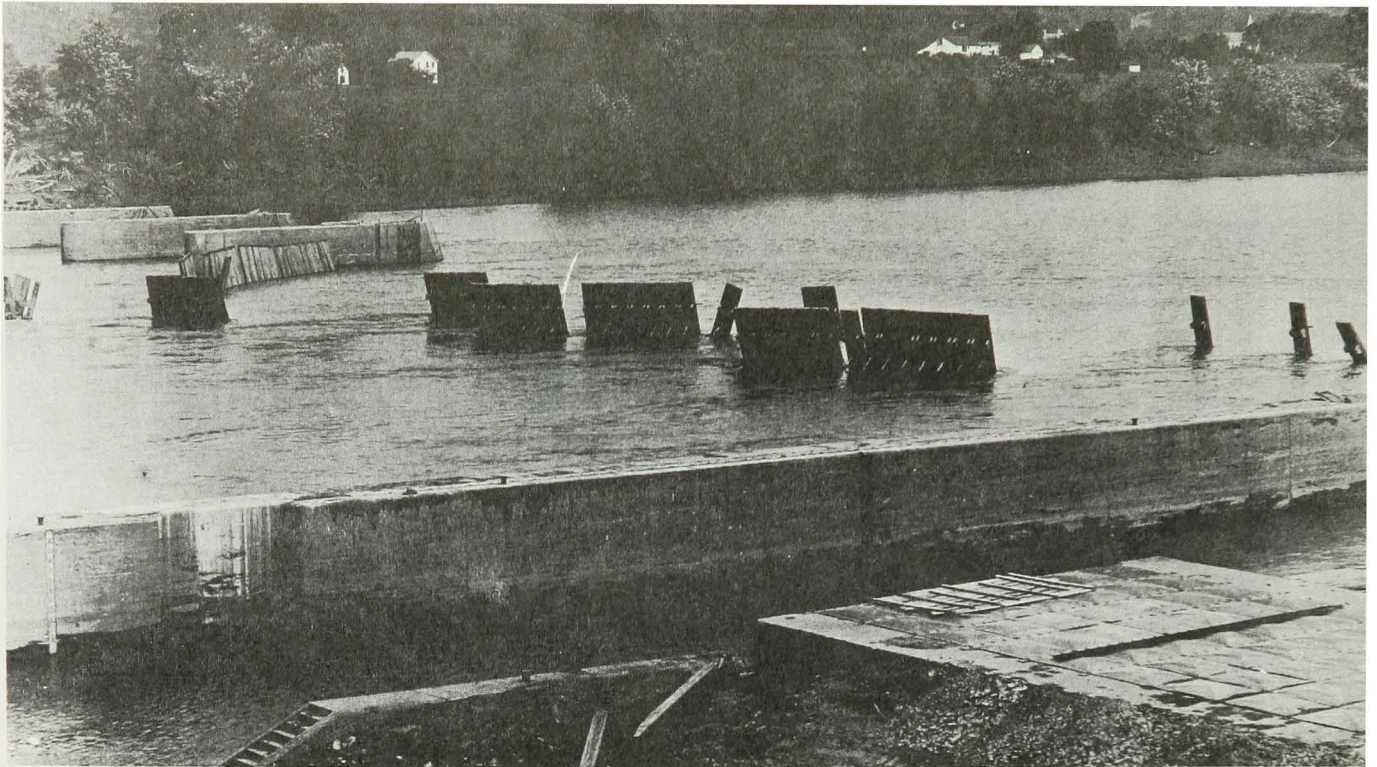
lock, 56 by 360 feet. A navigation pool 18.4 miles long was created, extending to Dashields Locks and Dam.

The Montgomery structure itself is in a forested area, but within the limits of the pool several significant industries are located, concerned with steel manufacture, slag, coal, oil, and barge building. One plant produces structural steel of sizes which could not be moved by truck or rail.

Montgomery averages about twenty commercial lockages daily, and during the summer months there are also many recreational lockages. Large amounts of steel, petroleum products, and other commodities are handled through the locks, but coal provides the bulk of the freight tonnage.

Gallipolis Locks and Dam

The Gallipolis Locks and Dam, a high-lift structure, was placed in operation in 1937 at River Mile 279.2, about fourteen miles downstream from the mouth of the Kanawha at Point Pleasant. It replaced three low-lift dams on the Ohio River and three on the Kanawha. The structure, built at a cost of \$10,400,000, was the most modern of the lock and dam projects prior to the Modernization Program. The locks are 110 feet wide, the main lock being 600 feet long and the auxiliary lock 360. The dam is 1,116 feet long and is equipped with eight roller gates, each 125.5 feet long, separated by 16-

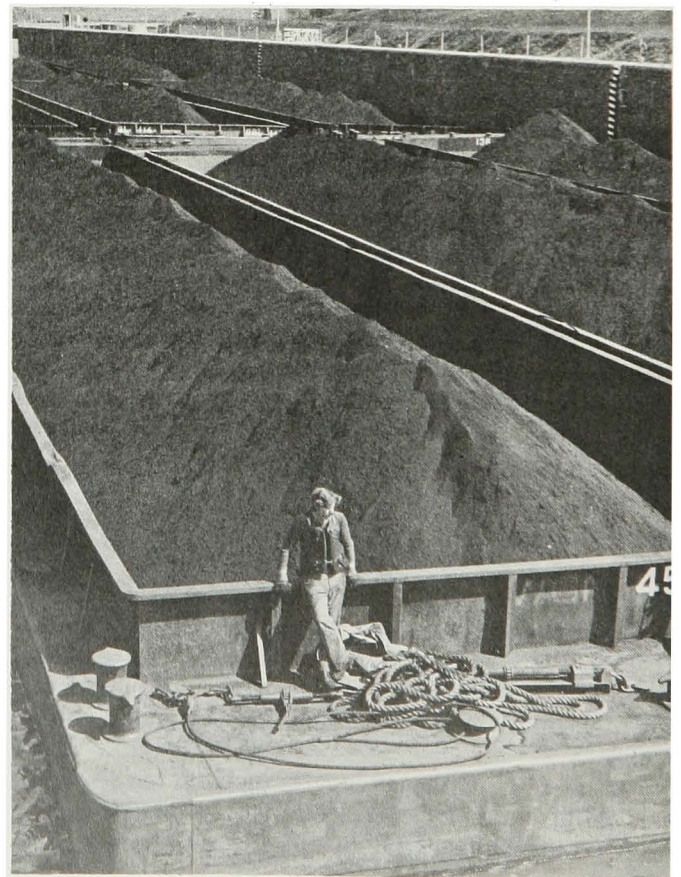


Lock and Dam 26 on the Ohio River on 7 August 1912. The structure was at River Mile 278.5, just above the subsequently-built Gallipolis Locks and Dam. Twenty-six had just been completed in 1912. Without advance indication the foundation under the navigable pass washed out, leaving the wickets in disarray. The dam was not reactivated until 1915

foot piers. The Gallipolis Dam is the only structure on the Ohio River equipped with roller gates, but the three Kanawha River dams built as a part of the same program also have roller gates.

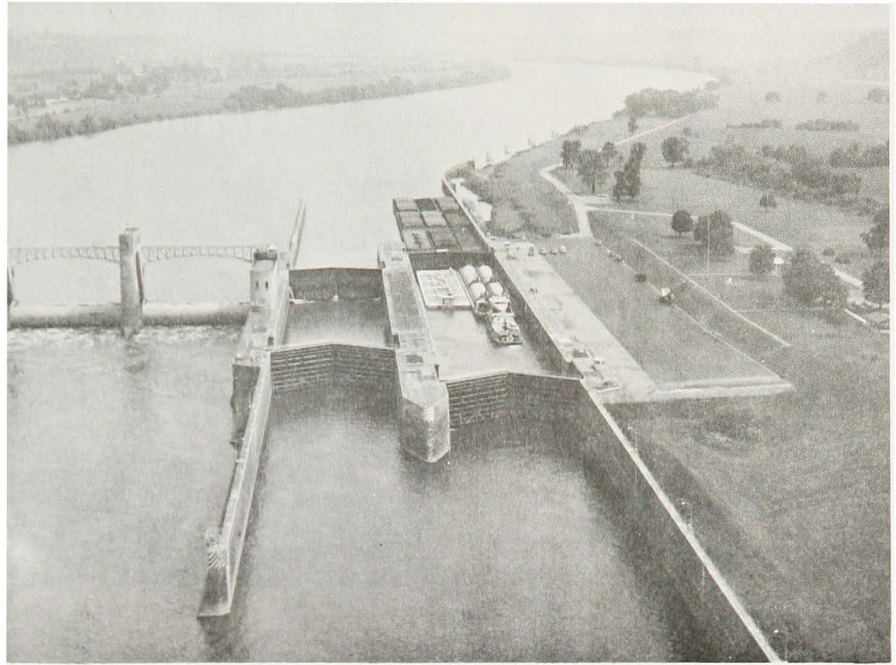
The Gallipolis structure was authorized as a part of the program for the improvement of the Kanawha River, but it is operated as a unit in the Ohio River navigation system.

Updating of the Kanawha River navigation system, including Gallipolis Locks and Dam, was recommended by the Corps of Engineers in 1932, approved by Congress in 1933, and funded by the Public Works Administration, a Depression work-relief agency. With



Coal barges being locked through Gallipolis

A characteristic double lockage at Gallipolis. A replacement plan under study contemplates a mile-long bypass canal through the river bend on the right



adequate financing available, the Gallipolis project was completed in four years, and replacement of the Kanawha navigation system as a whole was accomplished in less than eight years. By replacing six previously existing navigation structures, the Gallipolis Locks and Dam served to reduce maintenance and operating costs, while at the same time expediting the movement of river traffic by reducing the number of lockages required.

The provision of a modernized navigation system on the Kanawha served as a catalyst to industrial development in the Kanawha valley, particularly of the chemical industry, which grew rapidly and in great degree. Traffic on the Kanawha was also greatly increased.

Replacement Lock at Dam 41

The existing 110- by 600-foot lock at Locks and Dam 41 (now McAlpine) was completed in 1921, and in 1930 the old two-flight lock structure was replaced with the existing single-lift 56- by 360-foot lock. By this means, the traffic-handling capacity of the structure was substantially increased, and convenience of use was improved.

Tygart Lake

To assure an adequate minimum flow for navigation needs on the Monongahela River and the upper Ohio, Tygart Lake was built in the period 1935-38 on Tygart Valley River, a formation stream of the Monongahela. The dam is a concrete gravity type structure, situated 22.7 miles above the junction with the Monongahela at Fairmont, W. Va. It is two miles above Grafton.

The project was authorized by the Public Works Administration in January 1934 and adopted by the River and Harbor Act of 1935.

Storage of 99,900 acre-feet is reserved for release during low rainfall periods. The lake is also a part of a coordinated Ohio River flood control system and serves water supply and pollution control functions.

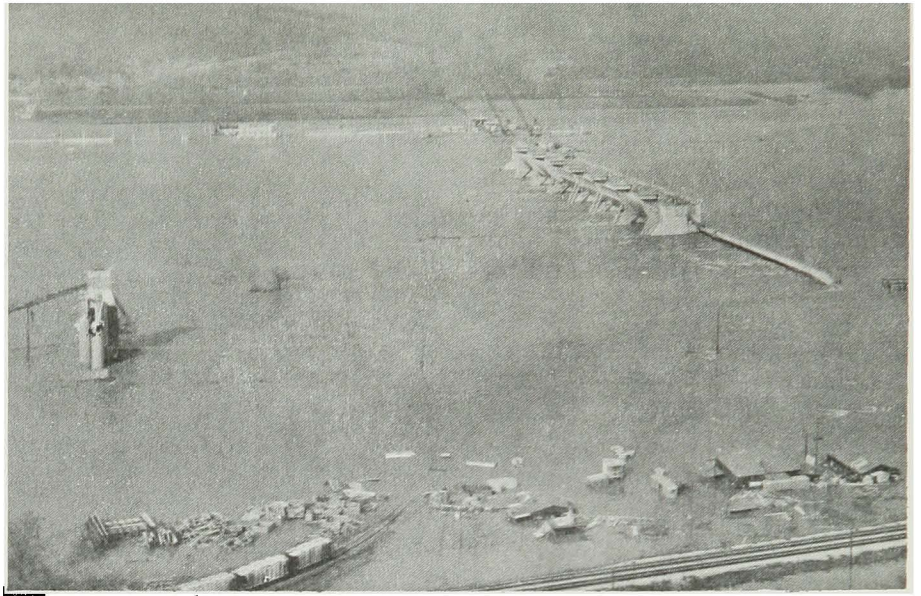
Reconstruction of Emsworth

The Emsworth Dams (on either side of five-mile-long Neville Island) were reconstructed in the 1935-38 period to provide gated crests and to raise the upriver pool by 7 feet. The project as rebuilt provided a 24-mile-long pool and made possible the elimination of the lock and dam structures numbered 1 on both the Allegheny and the Monongahela. The new pool extends 6.7 miles up the Allegheny and 11.2 miles up the Monongahela, giving Pittsburgh a water frontage of nearly fifty miles on a single navigation pool. Most of this frontage is intensively developed for industrial and commercial use.

The main channel dam is 967 feet long, including eight 100-foot-long vertical-lift gates with a fixed sill elevation of 698.0 feet above sea level. A normal upper pool level of 710.0 feet is maintained. The back channel dam has a length of 750 feet and has six vertical-lift gates. The overall cost of the project was \$5,862,000, including \$2,779,000 for reconstruction of the dams.

The gates on the Emsworth dams are operated to keep the pool at Pittsburgh constant except during periods of very high riverflow. The navigation locks raise and lower boats 18 feet between the downriver and upriver pools. Lockages average about thirty per day.

*Captain Anthony Meldahl
Locks and Dam on 12 March
1964, when construction was
interrupted by high water*



A Modernized System

After a dip during the Depression years of the early 1930s, river traffic on the Ohio resumed its climb, though with occasional off years related to economic trends. 1942, with 38 million tons moving on the river, was the peak year of wartime commerce in terms of tonnage—though not in ton-miles—on a system of locks and dams planned in 1910 to handle 13 million tons annually. 1945, with 34 million tons, was an off year, but traffic again resumed its uptrend and in 1950 approached 49 million tons.

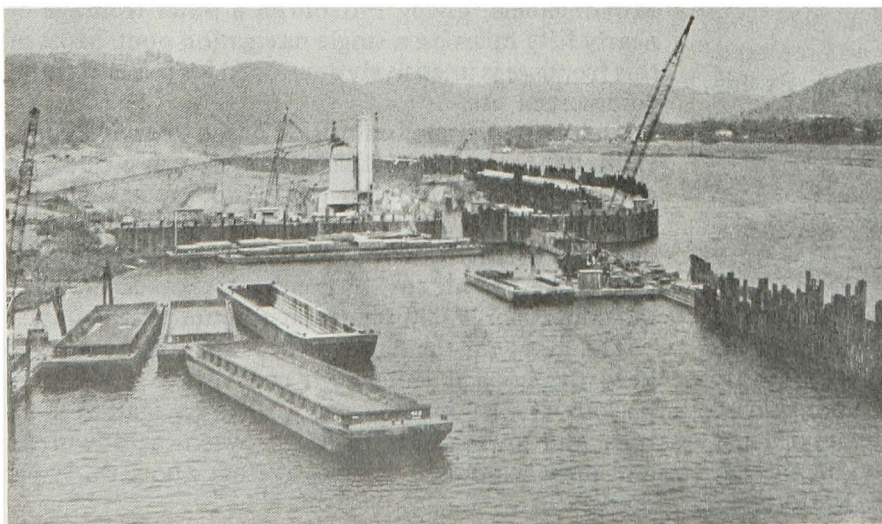
Need for Project Improvement

Not only had traffic volume grown tremendously, but, as an economy measure, 1,000-foot tows had come

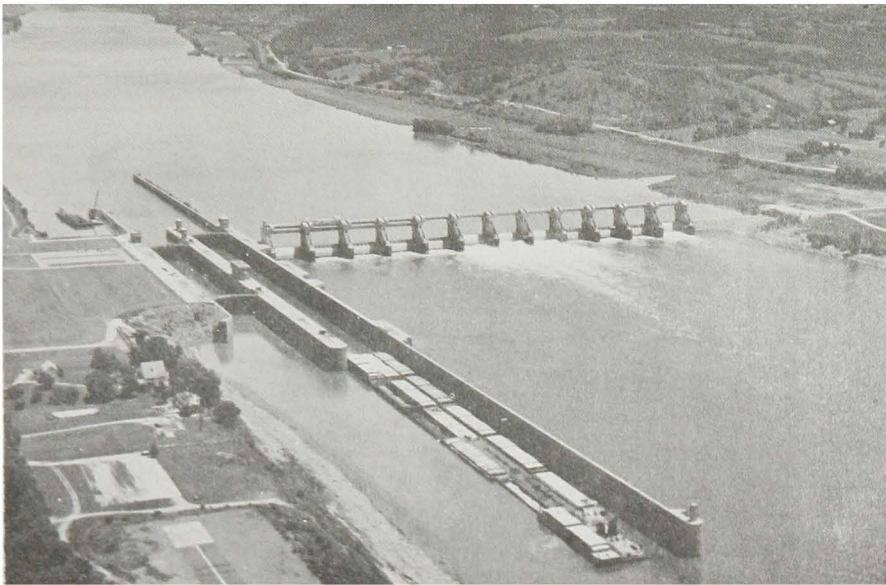
into use, and these had to be broken up to be passed through the 600-foot lockchambers.

By the 1950s, with growing commerce on the Ohio River, the low-lift navigable dams and 600-foot-long lockchambers had become obsolescent, and, in a measure, an impediment to the navigation they were designed to facilitate, since the locks could not handle many of the tows at a single lockage. Also, deterioration of the structures had taken place in varying degree, calling for increasing costs of maintenance and rehabilitation. At the same time the need of higher dams—with longer navigation pools—and locks of greater capacity had become evident.

The adequacy and effectiveness of the navigation system is kept under constant review by the Corps of Engineers, and in light of the conditions indicated, the



*An upriver view of construc-
tion in progress on Hannibal
Locks in October 1968*



An upbound tow entering the 1,200-foot lockchamber of Captain Anthony Meldahl Locks and Dam, June 1968

need of a full-scale modernization program was recognized, and detailed planning was begun. The program was approved as a going operation on 11 March 1953.

Design Features

The consensus of river navigators was that a 110- by 1,200-foot lock could handle the largest barge tow which could be operated efficiently on the Ohio. The Corps, agreeing with this view, accordingly designed new locks with these dimensions. An auxillary 110- by 600-foot lock was also planned at each structure to assure dependability and to provide flexibility and additional capacity.

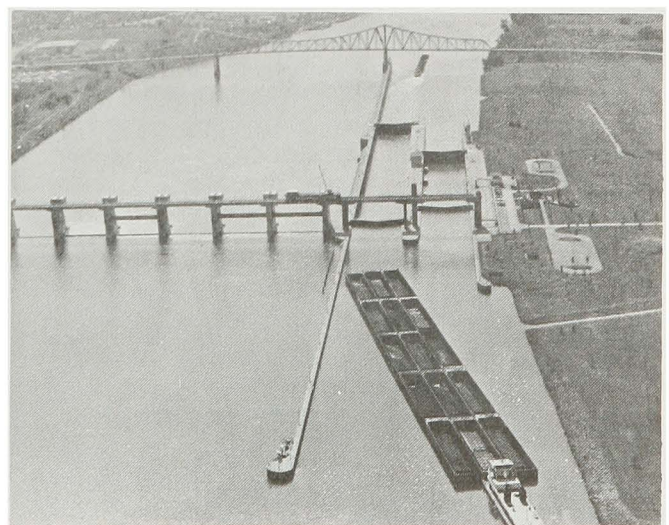
Project design called for nonnavigable dams with low fixed sills, equipped with movable tainter gates. These are massive radial steel gates (named for Jeremiah B. Tainter) used for regulating the flow of water over a spillway or dam. The upstream face of the gate is in the form of an arc centered on the gate hinge. The gates can be raised high enough to clear the highest floods, and thus do not impede waterflow during high water.

The locks are equipped with an improved conduit and valve system which permits filling and emptying the locks in about eight minutes, compared with the eighteen minutes required at the old locks.

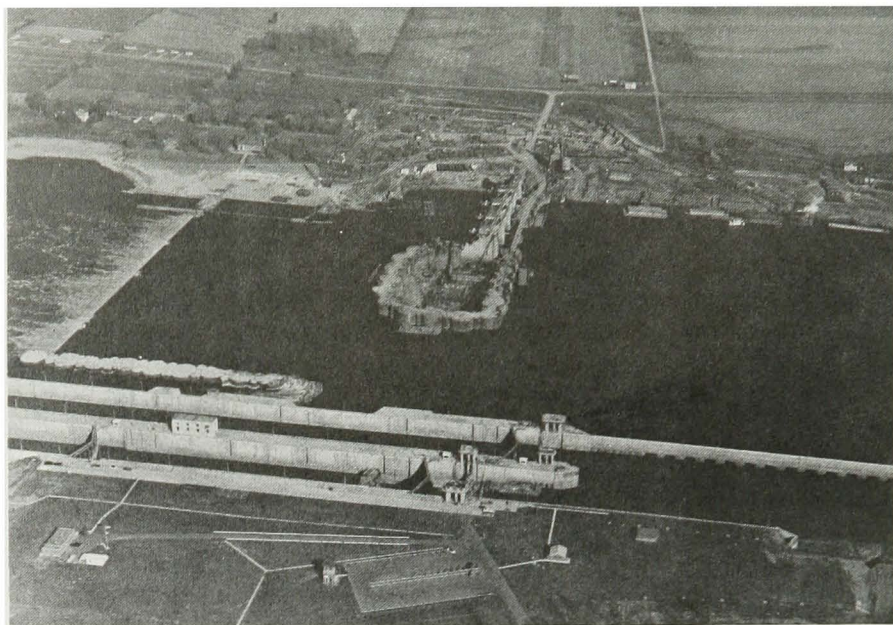
Prior Changes

Following completion of the 9-foot project depth on the Ohio River in 1929, and before modernization was begun, three navigation structures had been built: the auxillary 56- by 360-foot lock at dam 41 (Louisville), 1930; Montgomery Locks and Dam, 1936; and Gallipolis Locks and Dam, 1937. After completion of the Gallipolis project in 1937, the Ohio River navigation system comprised forty-six projects: forty-one movable and navigable (wicket) dams and five non-navigable dams. Two of the latter—Emsworth (1921) and Dashields (1929)—were included in the 1929 waterway, having already replaced the original lock and dam structures 1, 2, and 3.

A downbound tow has just left the 1,200-foot lockchamber at Hannibal, and another is about to enter. A 1978 photograph



A cofferdam stage in the construction of Markland Locks and Dam, November 1961. Immediately downstream from the new dam may be seen Lock and Dam 39, one of the five low-lift structures Markland replaced



Twenty-five Years' Work

Construction under the Modernization Program got under way in 1954 with the beginning of work on Greenup Locks and Dam. In terms of construction to mid-1979, the program involved the building of thirteen new high-lift lock and dam structures—including Smithland Dam, which was not yet quite completed—to replace thirty-nine low-lift lock and dam structures. The thirteen new dams have lifts ranging from 16 to 35 feet and provide navigation pools with average length of fifty-nine miles, comparing with lifts ranging from 5.6 to 11 feet and an average pool length of under twenty miles for the thirty-nine replaced structures. In addition to the new complete lock and dam structures, a 1,200-foot lock had been added at Louisville, where a

new dam was not required to maintain the desired up-river depth.

The Modernization Program provided for the progressive replacement of the low-lift navigable structures with a smaller number of fixed, nonnavigable structures of higher lift. The 9-foot authorized navigation channel was continued, but 1,200 feet was established as the length of the new main lock, double the 600 feet which was the standard for the system as originally built.

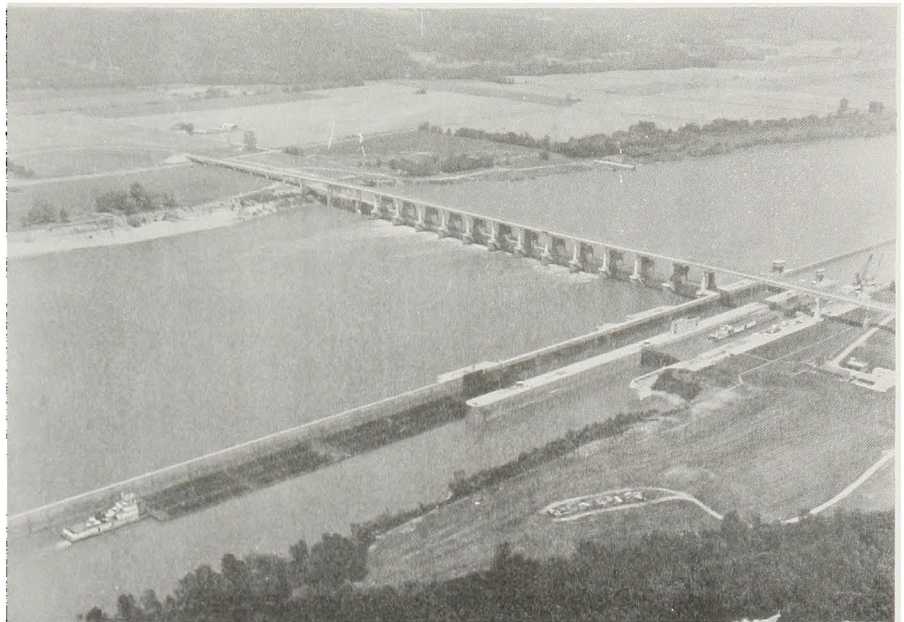
Order of Construction

In the construction programming, priority was given to river reaches where traffic was heaviest. Thus, the



A downbound tow pushing into the 1,200-foot lockchamber at Greenup, May 1978. Greenup replaced five low-lift lock and dam structures. Work on the project was begun in October 1954 and the pool was raised to full height 4 June 1962

A fifteen-barge coal tow entering the 1,200-foot lockchamber at Markland, 5 June 1979. The dam supports a highway bridge, completed in 1978. An 81,000-kva hydroelectric plant is operated at the abutment or Indiana end of the dam



New Cumberland, Greenup, Meldahl, and Markland structures were the first to be undertaken, with the locks at the first three of these locations placed in operation in 1961 and at Markland in 1963.

The Greenup project was located so that its pool would serve the port of Huntington, which in 1953 had topped Pittsburgh as the busiest port on the waterway. Coal by the millions of tons was moving by rail out of West Virginia and Kentucky fields to Huntington, where it was dumped into barges for delivery to Ohio valley industries and steam-electric powerplants. In 1974 the port handled 12 million tons, mostly coal and coke and petroleum and petroleum products.

New Cumberland Locks and Dam was undertaken to give continuity with the three already existing high-lift lock and dam structures upriver.

The Captain Anthony Meldahl Locks and Dam was the next new structure below Greenup Locks and Dam.

Markland Locks and Dam, with a lift of 35 feet, replaced five old lock and dam structures (35, 36, 37, 38, and 39), its pool extending about ninety-five miles.

In addition to the thirteen complete lock and dam structures built under the Modernization Program, a new 1,200-foot lock was built at McAlpine (Louisville) to update the busy structure at the former Falls of the Ohio, but the level of the upriver pool, 420 feet above sea level, was not altered. That level had been attained with the completion of Dam 41 in 1921.

Modernization Remainders

Of the authorized replacement structures under the Modernization Program, Mound City, the one

farthest downriver, remains in an indeterminate status in 1979, pending a reassessment of navigation requirements on the lower Ohio. Various other modernization steps also remain to be accomplished. Some of these are touched upon in the final section of this booklet, concerned with the future of Ohio River navigation.

Effect of Ohio River Dams on Flooding

The Ohio River dams have no measurable effect on flood heights. They provide pools for navigation when the flow of the river is inadequate for that purpose, but as the riverflow increases, the flow-control gates are opened gradually and the excess flow passes under them. In this way, the normal pool level at the dam is maintained.

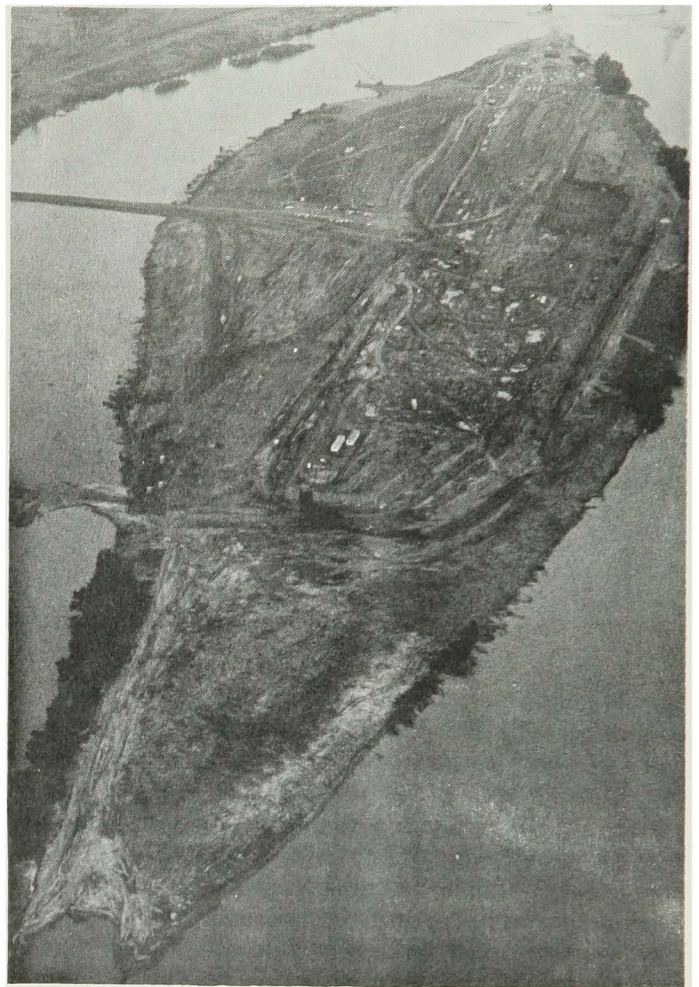
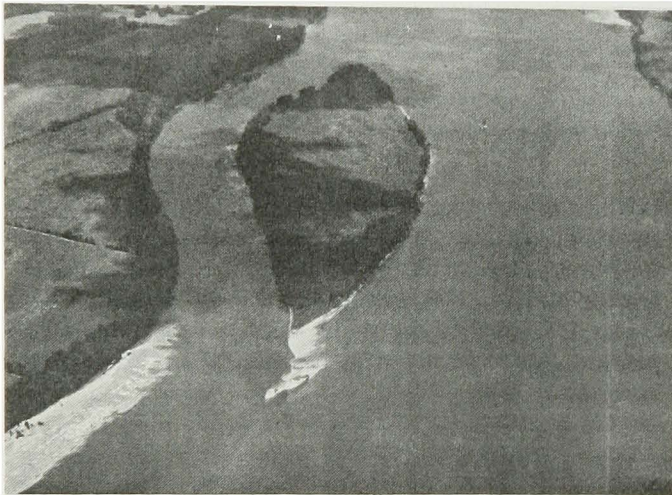
If the flow continues to increase, the normal pool level can be maintained by the natural flow of the river, and the gates are lifted entirely clear of the water. If the level of the water continues to rise it is because the flow of the river has exceeded the natural capacity of the channel at the normal pool level. As the river level rises above the normal pool level at the dam, the dam, with its gates out of the water, offers no more obstruction to the stream than the piers of a bridge. Thus, since the gates begin to open as flows begin to increase, a flood will not reach its crest any sooner than it would if there were no structure in the river.

Dog Island

and what happened there

Below: The island, near the Illinois shore of the Ohio River, in August 1970

Right: Progress on Smithland Locks, September 1971



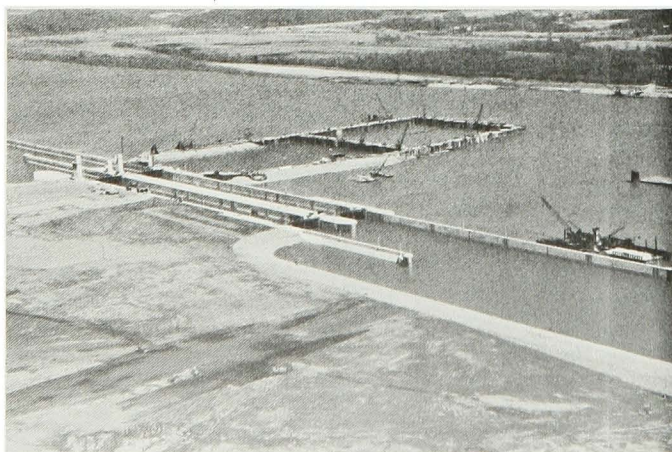
Numerous islands occur in many reaches of the Ohio River, and more especially in its lower course. Among these was Dog Island, hugging the Illinois shore of the Ohio some sixty miles above its junction with the Mississippi.

As it worked out, the island was at the site selected for Smithland Locks and Dam—first designated Dog

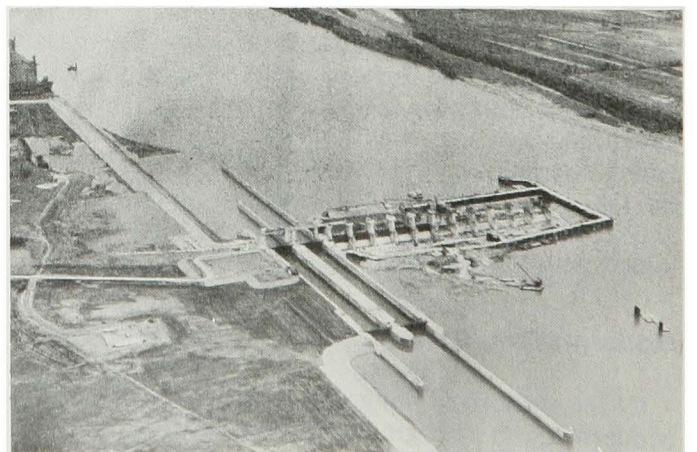
Island Locks and Dam—and in the construction of the locks the island itself was extinguished.

Because Smithland is the latest and close to the final undertaking in the Ohio River Modernization Program, it has been chosen here for a pictorial showing of stages in the construction of such a project.

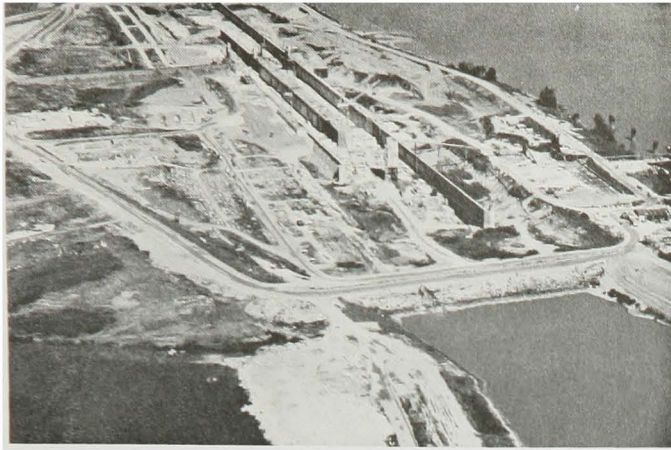
Eight accompanying aerial photographs show the



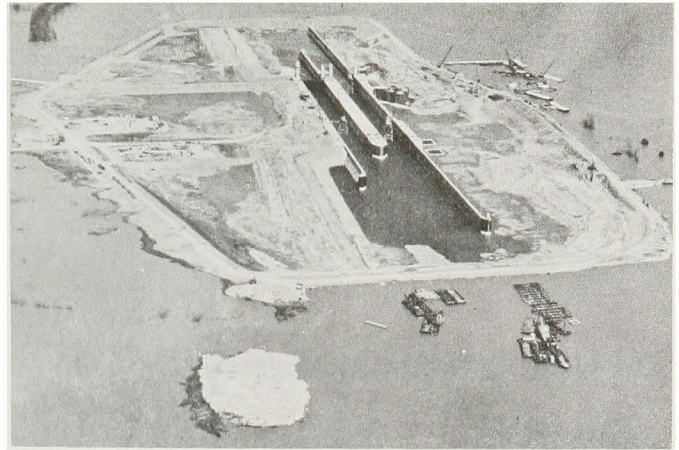
Cofferdam nearing completion for gated section of Smithland Dam, March 1977



Work in progress on gated section of dam, April 1978



Locks in progress on island, October 1974



Smithland Locks nearing completion, March 1975

project at intervals over a nine-year period, beginning with the island itself, as it appeared in August 1970. The most recent photograph, taken in July 1979, shows work in progress on the second stage of the dam.

As may be seen from the photographs, construction of the project was divided into three phases: (1) the twin locks, built along the Illinois side of the river, (2) a tainter-gate section of the dam, and (3) a fixed weir section of the dam, extending to the Kentucky side of the river.

Location and Purpose of Project

Smithland Locks and Dam is 918.5 miles below Pittsburgh and 62.5 miles above the junction of the Ohio with the Mississippi. It is two miles above Smithland, Ky., where the Cumberland River joins the Ohio, and 16 miles above Paducah, Ky., where the Tennessee enters the Ohio.

The new structure will serve as a replacement for the existing but obsolete Lock and Dams 50 and 51, at

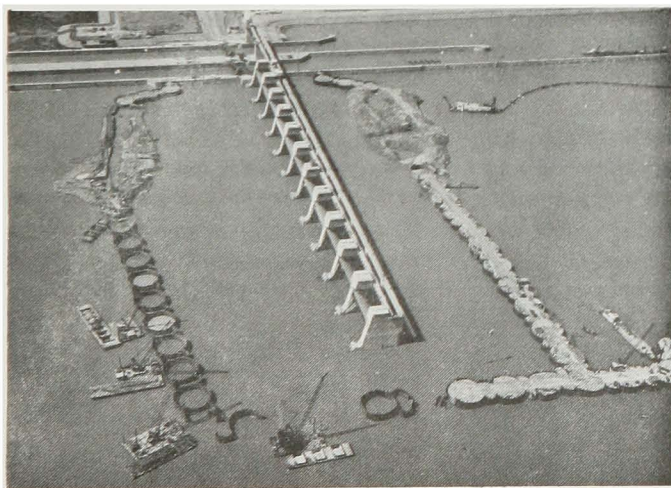
River Miles 876.8 and 903.1. These will be removed after the Smithland project becomes fully operational. The Smithland pool will then extend seventy-two miles upriver to Uniontown Locks and Dam (completed in 1975), and one of the two lockages previously required in this reach of the river will be eliminated.

The lift of Smithland between the lower and upper normal pool levels will be 22 feet.

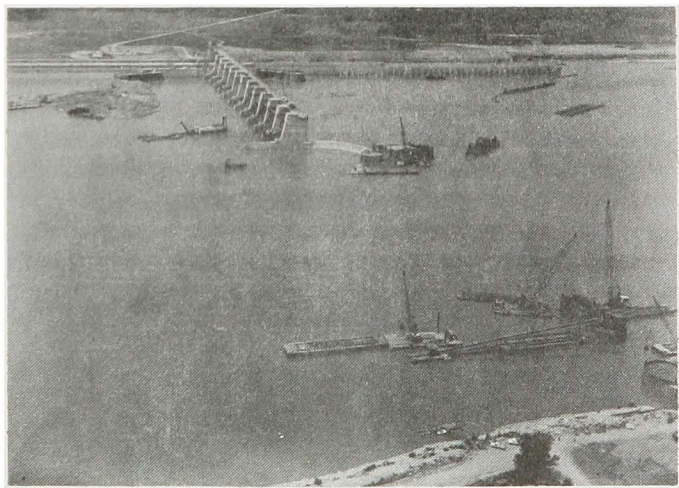
Because of an unexpectedly heavy development of traffic on the lower Ohio, especially coal, two 1,200-foot-long locks were constructed at Smithland instead of one 1,200- and one 600-foot lock, as at the previously programmed upriver structures. With two 1,200-foot lockchambers, this is the first navigational structure of its size on the Ohio River, and, as well, the world's largest twin-lock system.

Authorization, Design, and Direction

Construction of Smithland Locks and Dam was approved by the Secretary of the Army in 1965 under



Cofferdam for gated section of dam in process of removal, April 1979



Fixed weir section of Smithland is well under way, July 1979

authority of Section 6 of the River and Harbor Act of 1909. Preconstruction engineering and design were begun in fiscal year 1966 by the Nashville District. Building of the locks was begun in July 1971 and completed in 1976. Construction of the dam was begun in July 1974 and is scheduled for completion in early 1980. Responsibility for construction was transferred from the Nashville District to the Louisville District in July 1977.

Contractors and Cost of Project

The locks contract was awarded 18 June 1971 to a joint venture of contractors consisting of Dravo Corporation of Pittsburgh, S. J. Groves & Sons Company of Minneapolis, and Gust K. Newberg Company of Chicago.

The dam contract was awarded on 9 August 1974 to a combine consisting of J. A. Jones Construction Company of Charlotte and the Nello L. Teer Construction Company of Durham.

Calculated at October 1978 price levels the cost of the project has been placed at \$252 million, including \$295,000 in nonfederal expenditure.

Construction Procedure

As may be seen from the photographic construction sequence, the Smithland locks were built longitudinally through the former Dog Island. A service mound has been built adjoining the locks on the Illinois side, the back channel has been filled, and an access road has been built to connect the locks with the Illinois highway system.

Features of Locks and Dam

The Smithland dam is about 0.6 of a mile long. A gated section 1,390 feet in length contains eleven 110-foot-long electrically-operated tainter gates, topped with a service bridge equipped with a locomotive-type crane for the placement of upstream emergency bulkheads. A 1,572-foot fixed weir section, abutting the Kentucky bank, will stand 2 feet above the upstream normal pool level. When the locks are closed because of high water, navigation will be able to pass over the fixed weir.

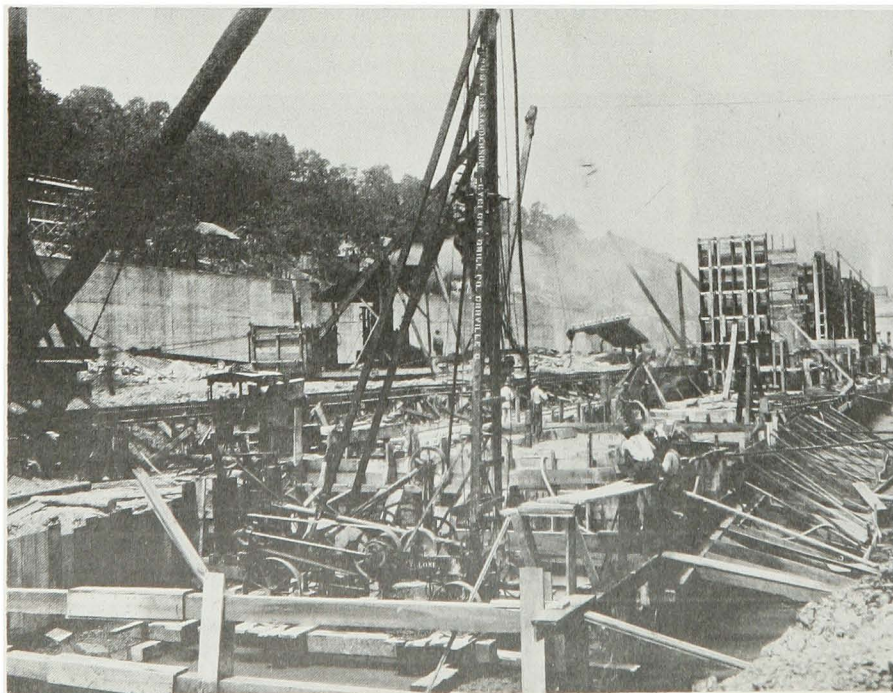
Each of the locks is closed at the upriver and downriver ends by horizontally framed all-welded miter gates. The two leaves comprising each gate weigh, together, on the order of 500 tons. Both the lock gates and the filling and emptying valves are hydraulically operated.

The water required for a single lockage is nearly 22 million gallons, enough to supply the residential needs of a city of 100,000 for a day and a half. A sidewall port system is used for filling and emptying the lockchambers. Each lock uses two water-flow tunnels—each large enough to accommodate a locomotive—and a lock can be filled or emptied in about eight minutes. The transit time for a tow through the locks is about forty-five minutes.

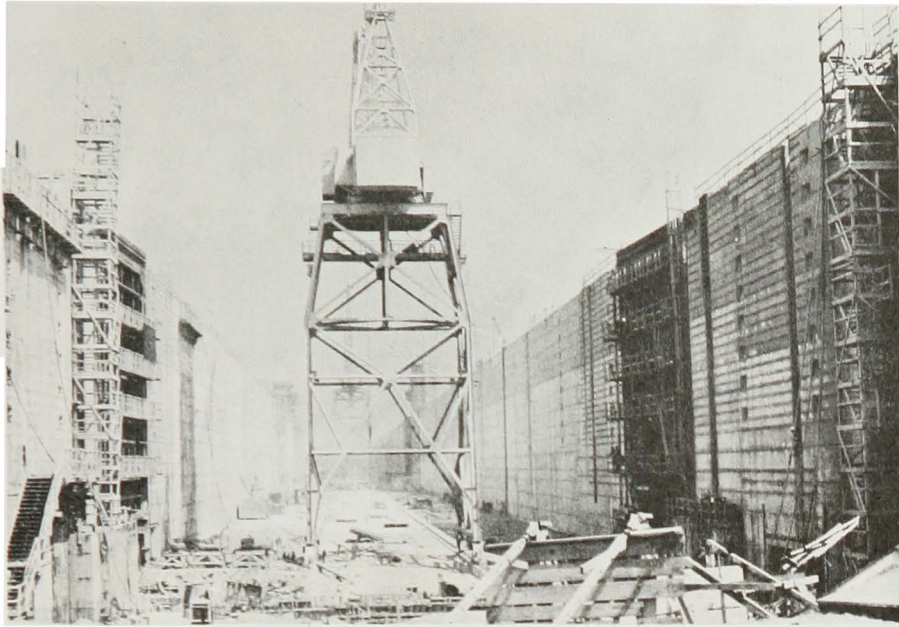
By the use of bulkheads, the culvert valves, the lock gates, and the lockchambers as a whole can be dewatered to facilitate required maintenance.

A Smithland Dam Antecedent

Smithland Dam is associated in point of location with a "dam" completed in 1834 under the direction of



*Construction on Lock 51,
August 1926*



A lock under course of construction at Smithland, July 1974

Henry M. Shreve. As described by Leland Johnson in the history of the Louisville District:

Cumberland Island [2.5 miles long], at the mouth of the Cumberland River, divided the Ohio River into two channels, or chutes. The main channel was down the right chute next to the Illinois bank, because a sandbar in the Kentucky Chute blocked access to Smithland, Ky., then an important commercial center and steamboat terminal where Cumberland and Ohio River packets exchanged freight. Downbound vessels took the right channel, circled the toe of Cumberland Island, and turned upstream to reach Smithland or enter the Cumberland. Captain Shreve and Captain Delafield planned a dam connecting the toe of Dog Island with the head of Cumberland Island, thus closing the right-hand channel and forcing water down the Kentucky Chute to scour away the sandbar. Rivermen protested the closing of the deeper right-hand channel, and citizens of Smithland feared the project would create currents sufficient to wash away the town wharf. Despite these objections, the project was authorized and, though interrupted by a cholera epidemic among the workmen, Cumberland Dam was completed in 1834. By 1837 Captain Shreve reported that Cumberland Dam, "where so much difficulty existed during the progress of the work, and for which

I was so much abused by the boatmen, is now a good channel."

Cumberland Dam—perhaps better termed a dike—was repaired and modified on several occasions during the following century, and was still in place and functioning during the construction of Smithland Locks.

Incident, however, to the opening of Smithland Locks, the downriver navigation channel is being shifted from the Kentucky side to the Illinois side of Cumberland Island. This will result in a slight shortening of the sailing distance, but at the same time it may be construed as lengthening the Cumberland River, which may now be considered as entering the Ohio at the downriver end of Cumberland Island.

Completion and Dedication

In September 1979, completion of the fixed weir section of Smithland Dam and the raising of the upriver pool were expected to take place in early 1980. The passing of river traffic through the locks was begun, however, in the fall of 1979, as work on the weir brought an end to open-channel navigation.

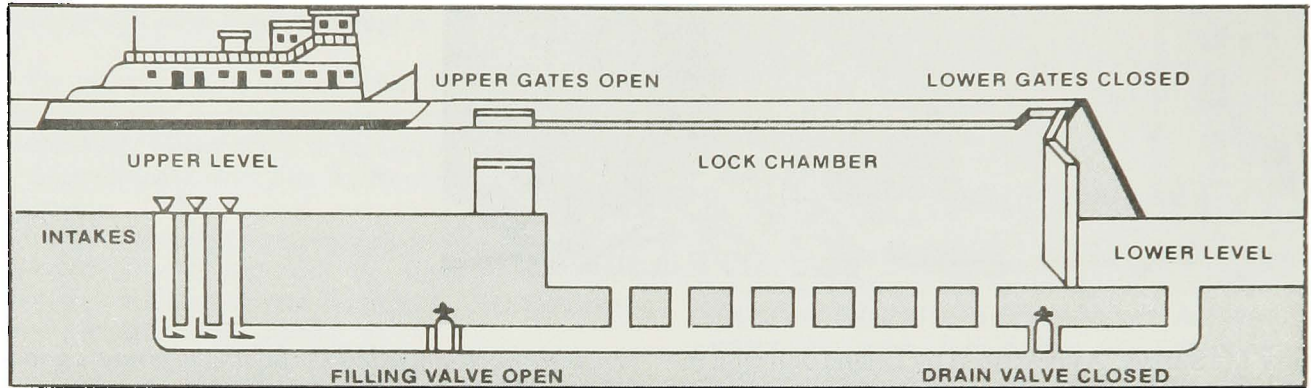
Dedication of Smithland Locks and Dam was scheduled for Saturday 27 October 1979 as a part of the 50th Anniversary observance of the Ohio River canalization.

How Navigation Locks Work

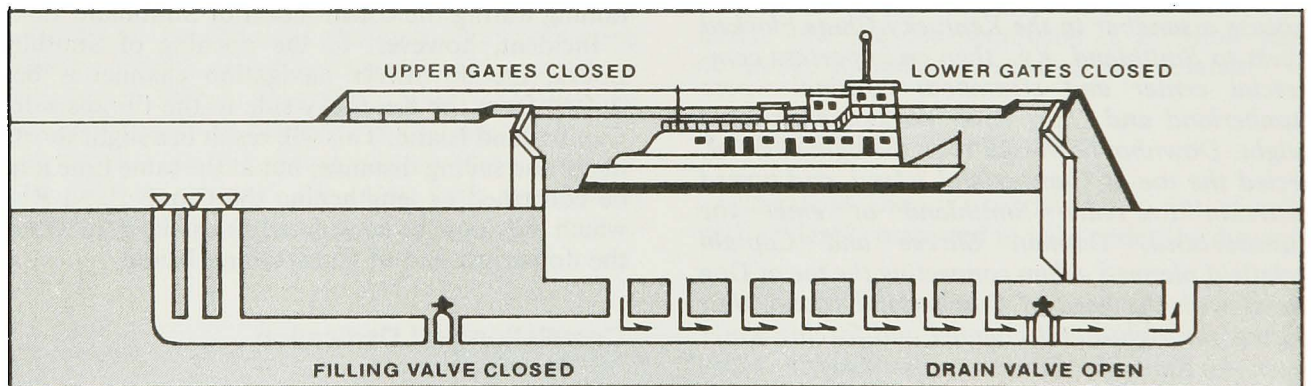
To provide adequate depth for navigation at all seasons, the Ohio River and major tributaries have been improved through the building of locks and dams. Each dam impounds a pool for navigation. The locks provide the means by which vessels are

raised or lowered from one pool to the next.

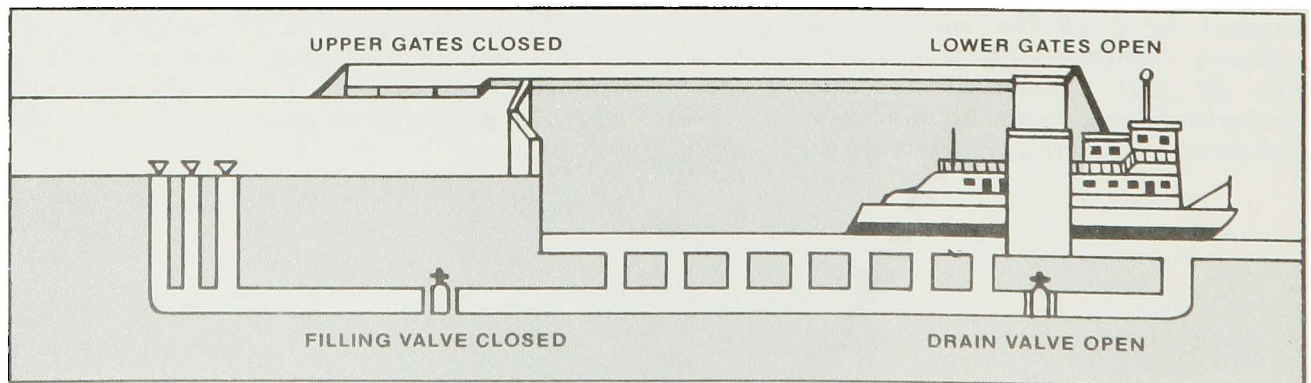
The accompanying diagrams show how locks function. A towboat is here being passed from the upriver to the downriver level.



The lower lock gates are closed; the drain valve is closed; the filling valve is open; the lock has filled to the level of the upriver pool; and the upper lock gates have been opened to allow the towboat to enter the lock



Now the towboat is in the lock; the upper lock gates have been closed; the filling valve is closed; the drain valve is open, allowing water to drain into the downriver pool. The towboat is lowered as the water level lowers



The water in the lock has here reached the level of the downriver pool. The lower lock gates have been opened and the towboat is leaving the lock to proceed on its way downriver



Barkley Lock and Dam under construction on Cumberland River (left) in 1963. Barkley Canal is being excavated in the dry to connect with Kentucky Lake (right)

Coordinating Two Rivers

The lower Tennessee and Cumberland Rivers have been developed to provide an exceptional degree of coordination with respect to navigation, flood control, power generation, and, as well, recreation. How this has been accomplished may be seen from accompanying photographs and captions.

In their lower courses the two rivers flow northward across western Kentucky to their junctions with the Ohio. For a distance of some forty miles—to the southward of Eddyville and Kuttawa—partly in Kentucky, partly in Tennessee, the streams are nearly parallel, about eight miles apart. To the north the courses are irregular, but at Grand Rivers they are little more than a mile apart.

Tennessee River Navigation

On the Tennessee River a 9-foot navigable depth has been developed throughout the 652-mile length of the stream (to Knoxville). That depth became fully operational in 1944, when Kentucky Dam, the structure farthest downriver, was completed. On the Tennessee, in contrast with the Ohio, the dams used for navigation are multiple-purpose structures, designed to serve the purposes of flood control and the genera-

tion of electric power as well as navigation. On the Ohio the dams have been built to serve the needs of navigation and do not possess flood control capability. (Run-of-river hydroelectric powerplants are in operation, under construction, projected, or planned at seven of the Ohio River dams.)

Navigation on the Cumberland

The Cumberland River improvements provide a 9-foot navigable depth for 385 miles, from the mouth to Celina, Tenn.—95 miles above Nashville. Four dams are used for this purpose. Like the Tennessee River projects, Barkley Dam, the structure farthest downriver, is a multiple-purpose project, providing for navigation, flood control, and the generation of electric power. The other projects providing for navigation also have power generation—though not flood control—as an indicated purpose. Barkley Dam is just across the narrow divide from Kentucky Dam. Its lock has been operative since 1964.

Vertical view (north at top) showing impoundment of Tennessee River (Kentucky Lake) on left; Cumberland River (Lake Barkley) on right. Two miles upstream from Barkley Dam is Barkley Canal, connecting the two lakes



A downbound tow locking through at Kentucky Dam. Kentucky Lake is in the background

Joining of the Two Rivers

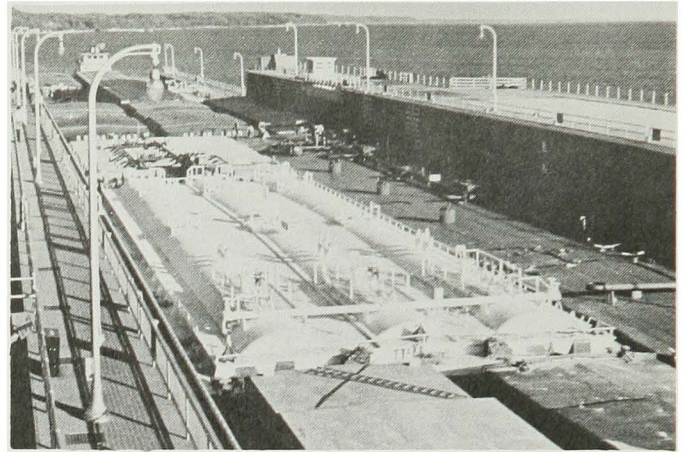
Two miles upstream from Barkley Dam, the Barkley Canal has been excavated to connect Barkley and Kentucky Lakes, and by this means the water levels of the lakes are equalized and alternate routes are made available for navigation. The two lakes are thus integrated in the interests of flood control and power production as well as navigation. Downriver flooding is further reduced because the equalizing effect of the canal causes each reservoir to exert a dampening effect on the flood crest of the other.

The alternative routings for navigation provided by Barkley Canal make possible savings in travel distances of five miles, twenty miles, and sixty-five miles, depending upon the points of origin and destination.

Barkley Lake has a length of 118 miles (to Cheatham Dam), and during the winter period, when major floods are to be expected, a capacity of 1,470,000 acre-feet is reserved for temporary retention of floodwaters. Kentucky Lake has a length of 184 miles (to Pickwick Landing Dam) and provides a floodwater reserve capacity of 4,000,000 acre-feet during the period of major prospective flooding.

Recreational Opportunity

By way of recreational opportunities, Kentucky and Barkley Lakes offer five Kentucky and Tennessee state parks, three National Wildlife Refuges, and the

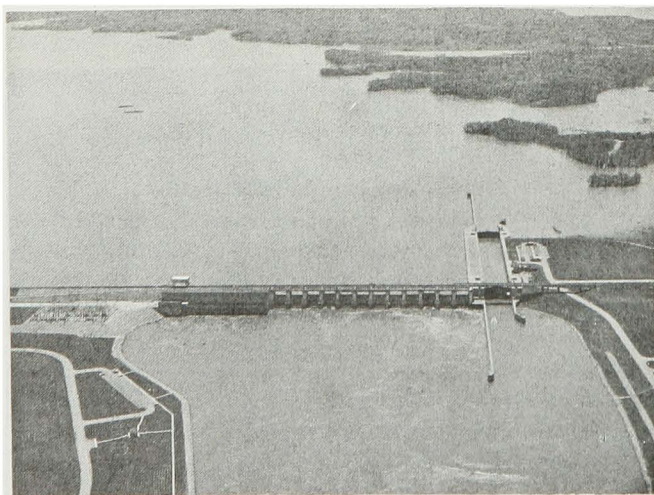


170,000-acre *Land Between the Lakes* recreation, conservation, and environmental demonstration area developed by the Tennessee Valley Authority. In addition, the Corps of Engineers maintains on Lake Barkley twenty-five recreational areas provided with boat launching, picnicking, and other varied facilities.

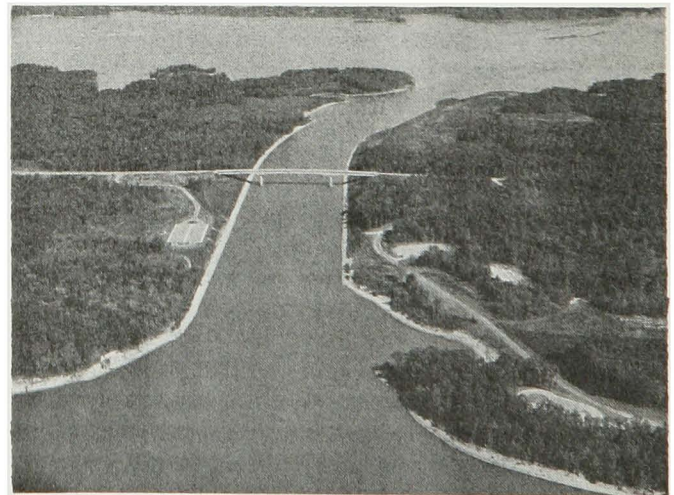
Nashville District and TVA

The Cumberland and Tennessee River drainage basins together form the Corps of Engineers' Nashville District. Since 1933 the Tennessee watershed as a whole has been developed under the aegis of the Tennessee Valley Authority, a federal corporate agency specifically organized to improve the Tennessee basin economy. Operation and maintenance of navigation facilities (locks and channels) is, however, the responsibility of the Corps of Engineers.

Together, the Tennessee basin (41,000 sq. mi.) and the Cumberland basin (18,000 sq. mi.) comprise 59,000 square miles or 29 percent of the 204,000 square miles making up the Ohio River basin as a whole.



Barkley Lock and Dam, fully operational in 1966. The canal (with bridge) may be seen right of center in middle distance



Barkley Canal, looking toward Lake Barkley. The canal equalizes the water levels of the two lakes and allows traffic interchange

Canalization of the Tributaries

A number of tributaries of the Ohio River were canalized before the main stream, for two significant reasons: (1) the navigation needs of the tributaries were, in the early period, more pressing, and (2) the problems of construction were of more manageable proportions.

In addition, the owners of the coalboat fleets originating on the Monongahela viewed dams on the Ohio as "obstructions" to the downstream sweep of their vessels on the flood tides which they considered essential to their operations. They therefore opposed Ohio River canalization.

The preceding section of this booklet, titled *Coordinating Two Rivers*, takes up two canalized tributaries of the Ohio: the Tennessee and the Cumberland. The other presently canalized tributaries are presented in this section: (1) the Monongahela, (2) the Allegheny, (3) the Kanawha, (4) the Kentucky, and (5) the Green-Barren system.

Omitted from treatment are former Corps-operated canalized tributaries: the Muskingum, the Little Kanawha, and the Big Sandy, as well as various non-federally developed canalizations, including the Coal (a Kanawha River affluent) and the Guyandotte.

Those desiring further detail on canalization of the Ohio River tributaries will find the Corps District histories of great interest.

A rather fine distinction may seem to exist between canals and canalization. Canals are touched upon only very incidentally in this booklet, however, as they had little bearing upon the development of the Ohio River basin navigation system as it ultimately developed. An exception is the Louisville and Portland Canal, a short though vital segment of the Ohio River main stem

navigation system, treated in the section titled *Falls of the Ohio*.

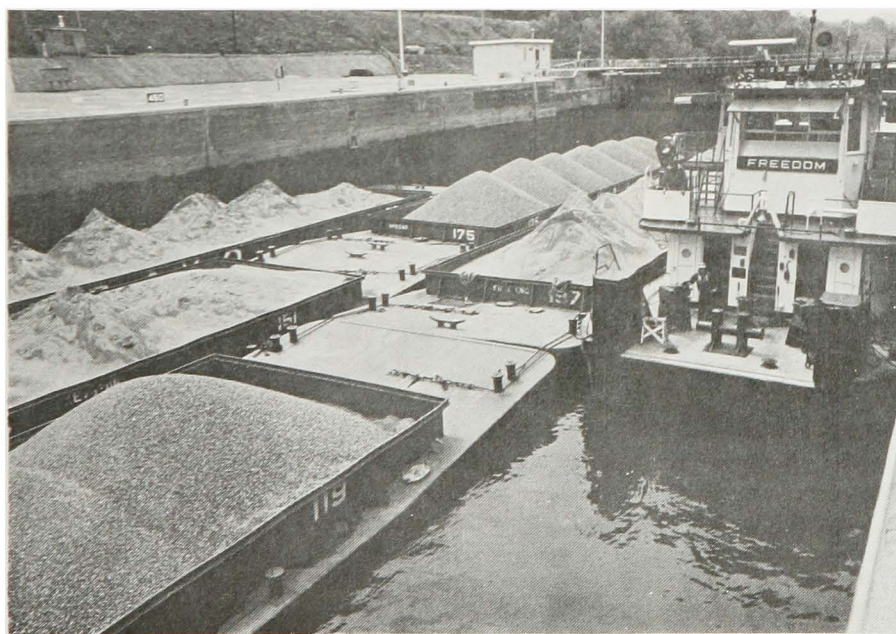
Monongahela River

The Monongahela is formed by the junction of the Tygart Valley and West Fork Rivers just south of Fairmont, W. Va. and flows northward 129 miles to its junction with the Allegheny at Pittsburgh to form the Ohio. For early migrants crossing the mountains from eastern Maryland and the Potomac section of Virginia, the Monongahela offered an opportunity to change from the difficult overland route to the comparative ease of water travel. The stream accordingly became the situs for the building of boats of whatever kind required. The Monongahela was in effect a part of the Ohio.

In 1760, sixteen years before the Declaration of Independence, the British sent skilled workers to Fort Pitt to build scows and bateaux (on the Monongahela) for military use on the western rivers. In 1777 boat-builders sent by the Continental Congress established their operations at McKeesport on the Monongahela.

George Rogers Clark set out initially in 1778 from the mouth of Redstone Creek (Brownsville), fifty miles above Pittsburgh on the Monongahela, where the keelboats for his expedition were built.

Upbound keelboat service on the Monongahela from Pittsburgh was announced in the *Pittsburgh Gazette* in 1782. In the same year a Brownsville-built vessel carried Monongahela produce to New Orleans.



Towboat with sand and gravel tow passing through lock on Monongahela River



The Point at Pittsburgh. The towboat Argonaut is shown returning from a trial run on the Monongahela.

The Point is reckoned as Mile 0 of the Ohio, the Allegheny, and the Monongahela.

Low-clearance bridges long impeded the canalization of the Allegheny

The steamboat *Enterprise* was built at Brownsville in 1814, sailed for New Orleans, and returned to its home port. From 1819, after the National Road reached Brownsville, and until 1852, stagecoach passengers regularly embarked by steamboat at Brownsville to proceed to Pittsburgh.

The factor in making the Monongahela one of the world's most heavily used waterways was, however, the tremendously rich coalfield traversed by the stream.

Canalization of the Monongahela was begun in 1839 by the Monongahela Navigation Company. Lock and Dams 1, 2, 3, and 4 were completed by 1844, with locks 50 feet wide by 158 feet long. The dams were rock-filled timber-crib structures and the locks were of cut stone laid in hydraulic cement. By 1886 the company had added three more lock and dam structures: 5, 6, and 7. Upriver slackwater navigation was provided through the construction of lock and dam structures 8 to 15 by the federal government in the 1874 to 1903 period, extending navigation to the head of the river.

After long negotiation the federal government took over the navigation company interests in 1897, and use of the river was freed from tolls.

Extensive replacement construction has since taken place. The latest modernization was begun in the late 1940s and is now about half way toward completion. This work includes new locks at Locks and Dam 2, a new higher dam at Locks and Dam 4 (allowing elimination of Locks and Dam 5), new locks and dam at Maxwell to replace Locks and Dam 6, a new higher lift dam at Lock and Dam 8, and new lock and dam structures at Morgantown, Hildebrand, and Opekiska to replace old Lock and Dams 10, 11, 12, 13, 14, and 15.

The present project provides improvement of the river with nine locks and dams, to a navigable depth of 9 feet.

Allegheny River

The Allegheny River was used for navigation from the earliest days of exploration and settlement, and its lower thirty miles was paralleled by the Pittsburgh end of the Pennsylvania Canal, opened in 1834. Canalization of the stream was, however, late in coming, largely because of low-clearance bridges, which had to be removed to permit modern commercial development.

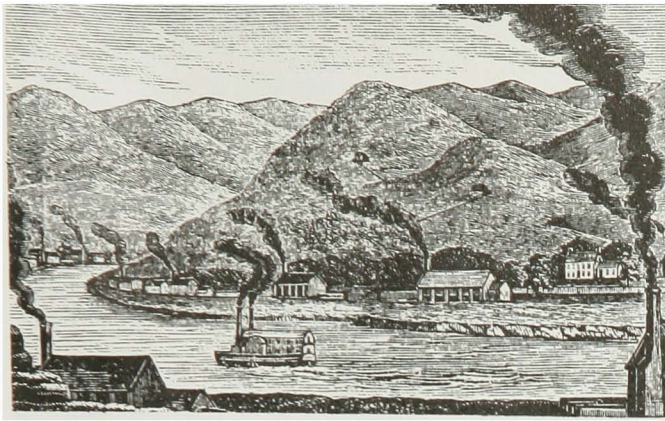
The present system, Lock and Dams 2 to 9, was constructed in the 1920-38 period. (Lock and Dam 1, completed in 1903, was removed after reconstruction of Emsworth Dams, 1935-38, added 7 feet to the pool level of the Ohio, Allegheny, and Monongahela Rivers at Pittsburgh.)

The existing project, with operational depth of 9 feet at normal pool levels, provides slackwater navigation for a distance of 72 miles. The locks are 56 feet wide and 360 feet long. The dams are fixed crest concrete structures.

Commercial use of the Allegheny has not developed as expected, its 5.1 million tons of traffic in 1977 comparing with 34 million tons on the Monongahela. The Allegheny is, however, heavily used by pleasure boats during the recreational season.

Kanawha River

Canalization of the Kanawha River was contemplated at the outset for two major purposes: (1) as a means of facilitating the downriver barge shipment of coal from the Kanawha coalfield; and (2) as a segment of the Cen-



Saltworks on the Kanawha as shown by Henry Howe. Salt was produced commercially before the coming of the steamboat

tral Water Line, a proposed trans-Allegheny water route which would link the Middle West with the Atlantic Coast at Hampton Roads. On the basis of the second of these purposes, responsibility for the Kanawha program was assigned in August 1874 to General William P. Craighill (later Chief of Engineers), the Engineer officer at Baltimore, who was in charge of the James River and Kanawha Canal.

The first federal appropriation for the Kanawha (for \$25,000) was made in 1873. Initial efforts were directed to cooperation with the West Virginia Kanawha Board, which was engaged in widening chutes and building new wing dams to provide a 4-foot depth over shoals.

Congress approved the Kanawha River slackwater project, and Davis Island, the first lock and dam project on the Ohio River, in 1875, and work was begun on Kanawha Lock and Dams 4 and 5 the same year.

As eventually built, the Kanawha system consisted of ten lock and dam structures. Notwithstanding flood damages to work in progress, labor problems, and

other vicissitudes, construction was pushed ahead and the system was brought to completion on 11 October 1898.

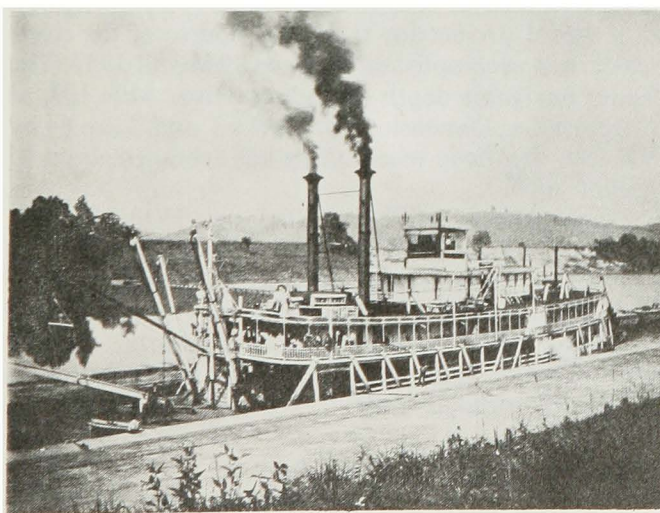
A 6-foot navigable depth was provided for some ninety miles upstream from the mouth. The two dams farthest upstream were fixed structures. The others were built with chanoine wickets, which could be lowered to provide a navigable pass during high-water periods.

By the time the Kanawha lock and dam system was completed the idea of a transmountain canal had long since been abandoned, and a lock and dam designated No. 1, to have been built a little below Kanawha Falls, was omitted as its function would have been to connect with the projected canal.

Building of the Kanawha system, which was accomplished at a cost \$100,000 below the original estimate, outdistanced the canalization of the upper Ohio and placed Kanawha coal shippers at a marked advantage over the mines on the Monongahela with respect to downriver markets. The system returned benefits far in excess of construction and operating costs.

The ten-structure low-lift system was replaced in the 1931 to 1937 period with four high-lift structures: Winfield, Marmet, and London Locks and Dams on the Kanawha, and Gallipolis Locks and Dam on the Ohio River below the mouth of the Kanawha. The modernized system provided a 9-foot navigable depth, the Kanawha dams being equipped with twin lockchambers with clear dimensions of 56 by 360 feet. Hydroelectric powerplants are operated at each of the three Kanawha River dams.

Steamboat Tacoma in Lock 9, below Winfield, on the Kanawha River, 1916



Dam 8, above Winfield, on the Kanawha

Deckhands prepare to drop off a load of alumina on the Green River

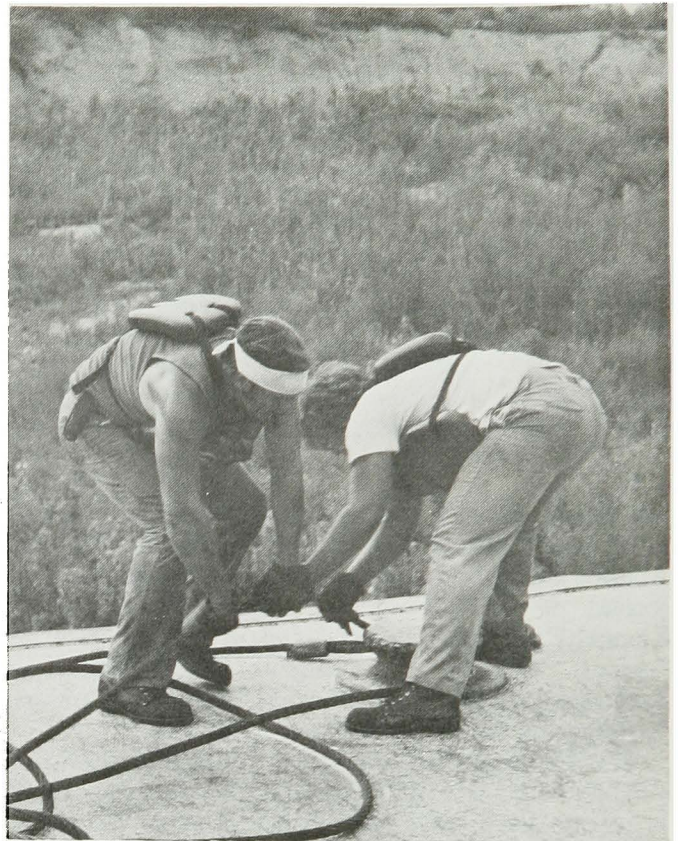
Kentucky River

Kentucky River enters the Ohio at Carrollton (1970 pop., 3,884), midway between Cincinnati and Louisville. The navigation system comprises fourteen locks and fixed dams, affording a 6-foot navigable depth from the mouth to the three formation streams, at Beattyville, a distance of 258 miles. The controlling lock dimensions are 38 by 145 feet. The only sizable community on the waterway is Frankfort (21,356), at River Mile 67, on the Dam 4 pool.

Construction of a slackwater project on the Kentucky was authorized by the state in 1835, and five lock and dam structures were built. The project was never profitable for the state, the toll collections, after payment of operating and maintenance costs, representing less than 1 percent annually on the original investment. The project did, however, stimulate development of the Kentucky River valley and adjoining portions of the Bluegrass, whose products were shipped to market at Louisville and other downriver points.

Following the Civil War, the state turned over the navigation system to a public corporation financed by the bonds of counties adjoining the river. The undertaking was found illegal, however, and operation ended in 1873. The system was conveyed to the federal government in 1880, and navigation was reopened to Frankfort the following year. By 1917 the government had built Lock and Dams 6 to 14, as well as rehabilitating the acquired structures.

Freight usage of the Kentucky River has had a varied history, but has never met expectations. The system is now used mostly by recreational boaters, though there is also an inbound movement of sand, gravel, and crushed stone on the lower course of the river. A hydroelectric plant is operated at Dam 7.



Green and Barren Rivers

The Green-Barren River canalization system was authorized by the Kentucky legislature in 1833 and completed by the state in 1841. The Green joins the Ohio about eight miles above Evansville, Ind. As originally designed the system provided a 5.5-foot navigable depth to Bowling Green, on Barren River, 180 miles from the Ohio.

The system was acquired by the federal government under authority of the River and Harbor Act of 1888. Traffic reached a peak of 591,000 tons in 1928 but dwindled to 25,000 tons in 1947. A surge of production from Green River coal mines then led to authorization of a 9-foot project for the lower course of the river, which was accomplished between 1954 and 1957. The 9-foot navigable depth extends to River Mile 103, at Chiggarrville. Dimensions of Locks 1 and 2 are 84 by 600 feet. Traffic in recent years has averaged about 16 million tons.

Original Lock and Dam 3 (lock size, 35 by 137 feet), constructed in 1833-36 at River Mile 108.5, continues in use, limiting traffic beyond to smaller barges. Dam 4 at Mile 149 on Green River failed in 1965, and barge use beyond that point is no longer possible. A pool above Dam 1 on Barren River is maintained, however, for use by pleasure craft.

II. Ohio Navigation as It Is Today

In three basic measurements the Ohio River Waterway of 1979 is the same as that of 1929. It is 981 miles long, its navigable depth is 9 feet, and its locks are 110 feet wide. But in fact, the Waterway has been greatly altered, to accommodate a tremendously increased volume of traffic.

The changes in the Waterway improvements have taken two major directions: (1) the replacing of the earlier low-lift lock and dam structures with a smaller number of high-lift structures with longer pools, and (2) the addition of 1,200-foot-long locks in the modern

projects to permit the expeditious passage of the longer modern tows, which could not be accommodated in a single lockage through the 600-foot-long locks which were the standard in 1929.

The progress which has been made in the modernization program may be seen from the accompanying table, which shows the Ohio River locks and dams as they are in 1979, with their River Mile locations, lock sizes, the years in which the locks were placed in operation, and the lifts—differences in elevation from one navigation pool to the next.

Ohio River Locks and Dams

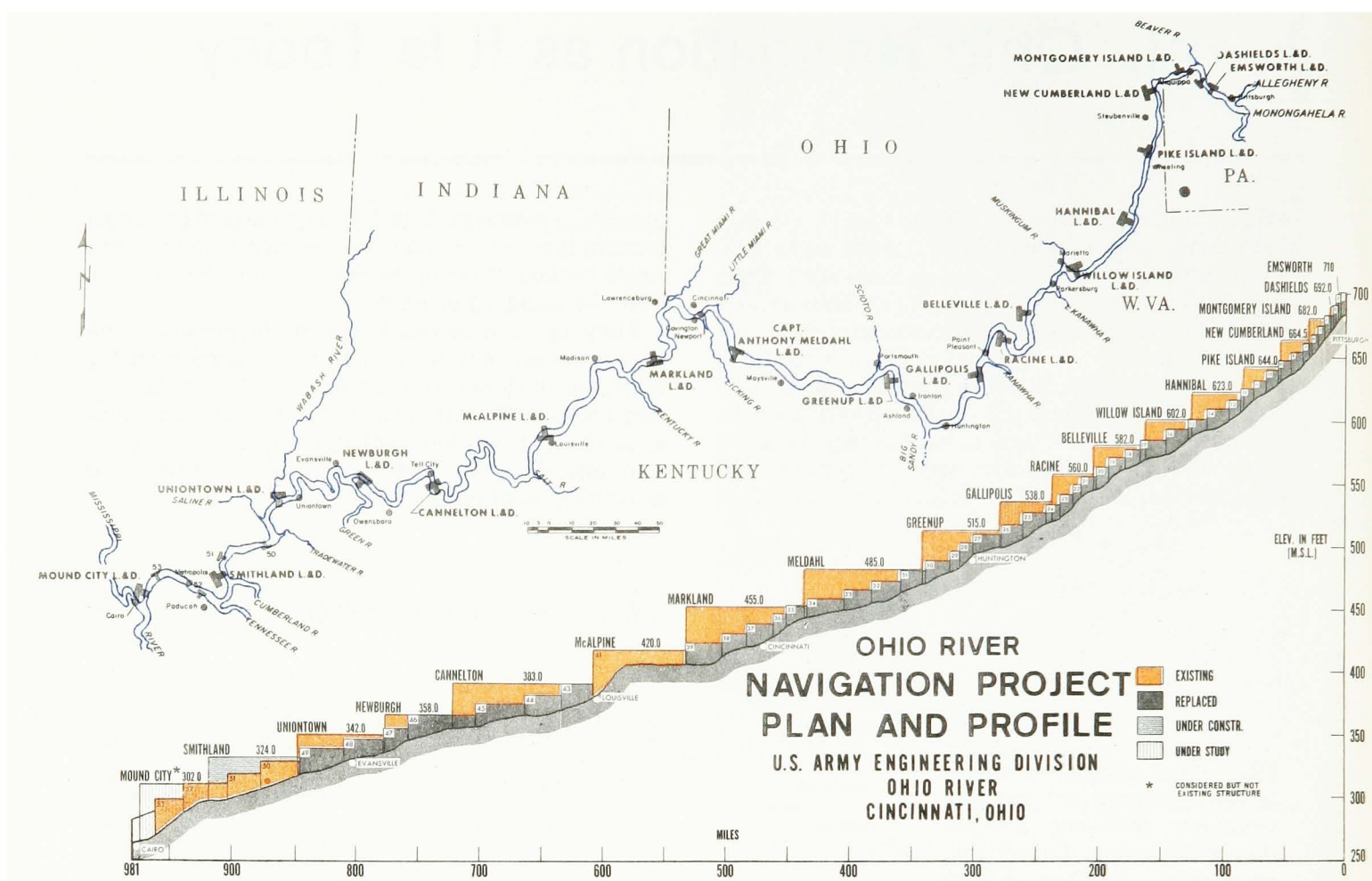
1979

Ohio River navigation will be served by twenty lock and dam structures following completion of Smithland Dam (1980), when structures 50 and 51 will be removed

Dam/Lock Designation	River Mile Location	Lock Sizes (In feet)		Years Locks Placed in Operation	Lift (In feet)
Emsworth	6.2	110 x 600	56 x 360	1921	18.0
Dashields	13.3	110 x 600	56 x 360	1929	10.0
Montgomery	31.7	110 x 600	56 x 360	1936	17.5
New Cumberland	54.4	110 x 600	110 x 1,200	1959	20.5
Pike Island	84.2	110 x 600	110 x 1,200	1963	21.0
Hannibal	126.4	110 x 600	110 x 1,200	1972	21.0
Willow Island	161.7	110 x 600	110 x 1,200	1972	20.0
Belleville	203.9	110 x 600	110 x 1,200	1967	22.0
Racine	237.5	110 x 600	110 x 1,200	1967	22.0
Gallipolis	279.2	110 x 600	110 x 360	1937	23.0
Greenup	341.0	110 x 600	110 x 1,200	1959	30.0
Meldahl	436.2	110 x 600	110 x 1,200	1962	30.0
Markland	531.5	110 x 600	110 x 1,200	1963	35.0
McAlpine	604.4	110 x 600	56 x 360 110 x 1,200	1921, 1930, 1961	37.0
Cannelton	720.7	110 x 600	110 x 1,200	1975	25.0
Newburgh	776.1	110 x 600	110 x 1,200	1969	33.0
Uniontown	846.0	110 x 1,200	110 x 600	1975	22.0
50	876.8	110 x 600		1928	10.0
51	903.1	110 x 600		1929	8.0
Smithland	918.5	110 x 1,200	110 x 1,200	1979	22.0
52	938.9	110 x 1,200	110 x 600	1969, 1928	12.0
53	962.6	110 x 600	110 x 1,200	1929, UC	13.4

UC = Under construction.

Note: In the listing of lock sizes, the landward lock is listed in the first position.



The profile shows the locations of all the navigation structures ever built on the Ohio River

Locks and Dams on the Main River

In all, the Ohio River lock and dam system in 1979 comprises twenty-two lock and dam structures—two of these will be eliminated when Smithland Locks and Dam is completed early in 1980. There is also the Louisville and Portland Canal, markedly altered from its primitive form of 1830, when it was first opened to bypass the Ohio River rapids.

Fourteen of the 1979 navigation structures comprise the modernized portion of the Ohio River Waterway. All of these contain 1,200-foot locks, placed in operation between 1961 and 1979.

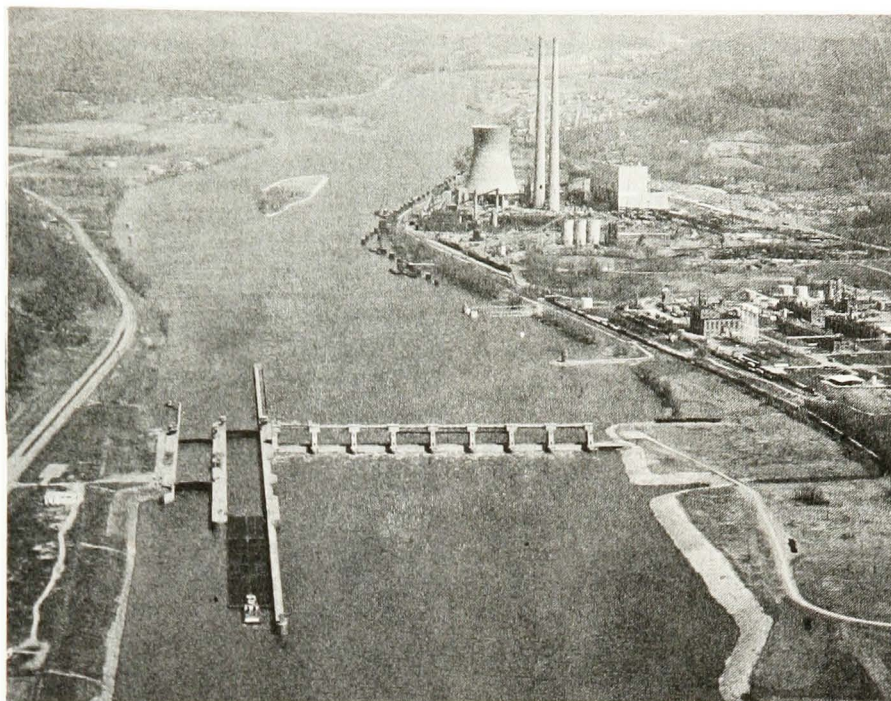
Four are named structures opened from 1921 to 1937 to replace original numbered structures. Each of these has two locks, but the larger lock in each case is 110 by 600 feet, which was standard in the original system. These four structures which are below present-day standards include the three nearest Pittsburgh—Emsworth, Dashields, and Montgomery—and

Gallipolis Locks and Dam, at River Mile 279.2. The Gallipolis structure, completed in 1937 and the most modern on the river at the time, replaced three Ohio River and three Kanawha River lock and dam structures.

Four of the present dams—50, 51, 52, and 53—were part of the Ohio River system as originally constructed. Dams 50 and 51 will be removed in 1980 (following completion of Smithland Locks and Dam), while 52 and 53 will be retained in use pending later resolution of the navigation problems along the lower reach of the river. In the meantime, a new temporary 110- by 1,200-foot lockchamber has been added at 52, and a similar structure is under construction at 53.

Of the fourteen modern structures already referred to, thirteen were entirely new installations, complete with dam and 1,200- and 600-foot locks, each built to replace two or more of the original low-lift structures. At Louisville, however, a 1,200-foot lock was added, and the dam was modified, the normal level of the up-river pool remaining unchanged at 420 feet above sea level. The lift from the lower pool continued at 37 feet. Because of the rapids it had never been feasible to build a single low-lift dam at Louisville.

Willow Island Locks and Dam, completed in 1976. A chemical plant of American Cyanamid Company is on the West Virginia side of the river, and next upstream is the Pleasants steam electric generating station of Monongahela Power Company



Pattern of the Ohio River Navigation System

The Corps of Engineers maintains a navigation channel with 9-foot authorized depth on the Ohio River from Pittsburgh to the mouth (981 miles) and on some 1,300 miles of tributary streams. The major tributaries and their navigable distances are: Allegheny River, 72 miles; Monongahela River, 129 miles; Kanawha River, 91 miles; Green River, 103 miles (plus 46 miles of 5.5-foot depth upstream from Mile 103); Tennessee River, 652 miles; and Cumberland River, 385 miles. The Kentucky River is navigable for 259 miles, but the navigable depth provided is limited to 6 feet and the lockchambers are too small for the use of standard Ohio River barges. (The Muskingum River has a navigable depth of 5 feet for a distance of 93 miles, maintained for pleasure craft by the state of Ohio, but the lockchambers are too small for standard commercial barges.)

Volume and Character of Traffic Flow

To illustrate the traffic carrying function of the Ohio River and its canalized tributaries, a diagram is presented showing the traffic flow on the inland waterways and the Gulf Intracoastal Waterway. The

Great Lakes waterway, with its adaptability to the use of deeper draft vessels, is omitted from the diagram.

The character of Ohio River traffic has changed considerably. Since 1925 coal has comprised about half the total tonnage moved on the river. The other half formerly consisted principally of stone and sand and gravel, but it is now made up mostly of oil and gasoline, iron and steel, and chemicals.

Types and Sizes of Towboats

Towboats as now constructed have from one to four propellers, each driven by a separate diesel engine. Several towboats having four engines with a combined horsepower of 10,000 are now in operation; they are 190 feet long and 54 feet wide and have a draft of 8.6 feet. The cost of building vessels of this size has run to about \$3,000,000.

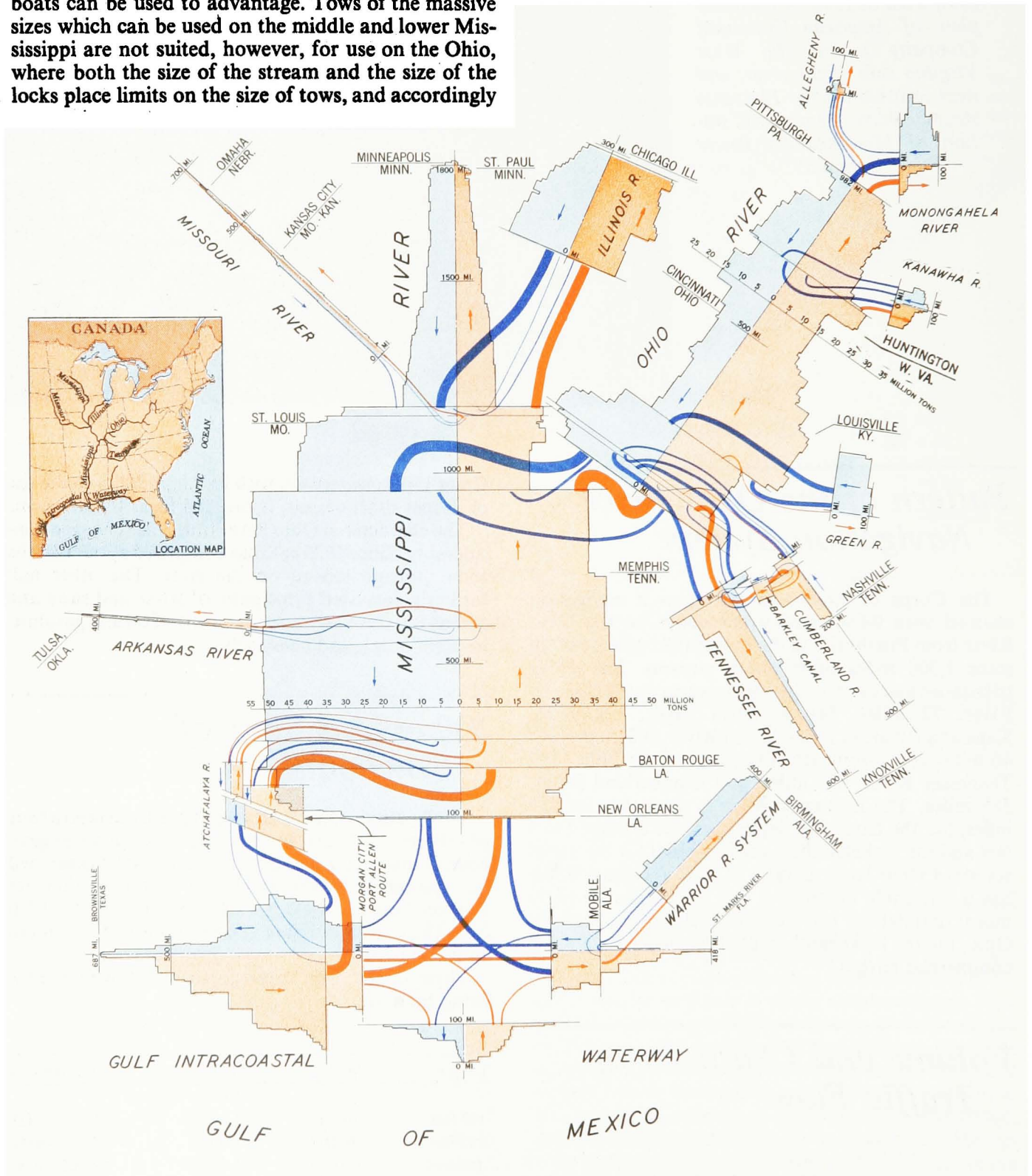
Three of the most common sizes of towboats now being built are:

Length	Width	Draft	Horsepower
117 feet	30 feet	7.6 feet	1,000 - 2,000
142 feet	34 feet	8.0 feet	2,000 - 4,000
160 feet	40 feet	8.6 feet	4,000 - 6,000

Towboats of 6,000 horsepower and more can push tows carrying 40,000 to 50,000 tons of cargo.

The sizes of towboats are determined by the waterway on which they are to be operated and on the work they are expected to do. The broad and unobstructed Mississippi below St. Louis lends itself to the use of large tows, for which more powerful towboats can be used to advantage. Tows of the massive sizes which can be used on the middle and lower Mississippi are not suited, however, for use on the Ohio, where both the size of the stream and the size of the locks place limits on the size of tows, and accordingly

on the power of the towboats which can be employed effectively. Small towboats can be used for moving individual barges, for assembling or disassembling tows, and for a variety of harbor work. Some of these are no more than about 12 feet wide by 36 feet long, with 6-



INLAND FREIGHT TONNAGE ON THE MISSISSIPPI RIVER SYSTEM
AND THE GULF INTRACOASTAL WATERWAY 1975



Towboat Peace with down-bound tow, near Ashland, Ky., as seen from pilothouse. The pilot has many modern aids. Among the advances: elimination of the steering wheel

foot draft, and propelled by an engine of about 100 horsepower.

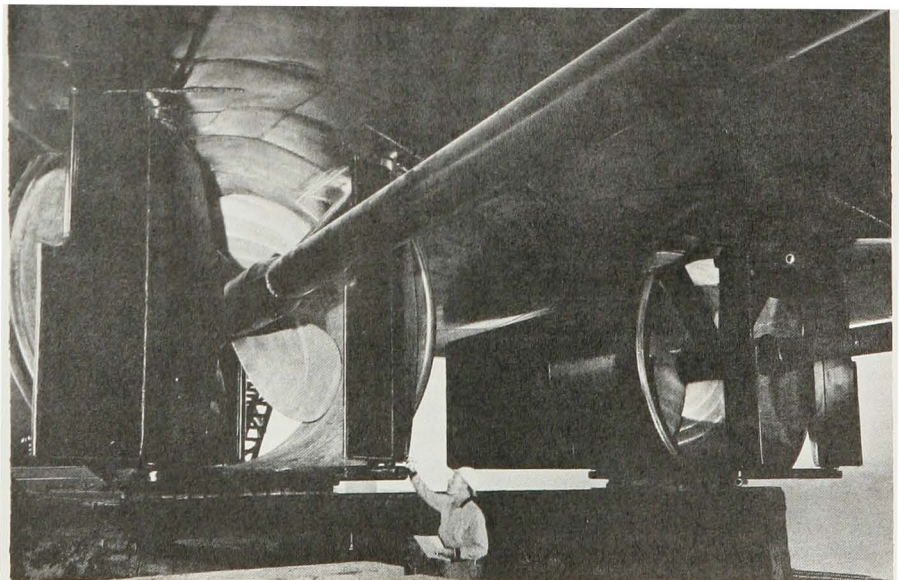
Towboat Improvements

A 1974 report showed that inland waterways tonnage tripled over a forty-year period. At the same time, the average length of haul increased from 50 to 375

miles. As a result the ton-miles of traffic generated increased twenty-twofold. Crew size was cut in half during the forty years, however, and productivity per man was thus increased fortyfold.

The strides made in the waterways industry were made possible by the development and adoption of "the medium speed diesel engine, the Kort nozzle, the tunnel hull, radar, swing indicators, and telecommunications," the report indicates. It is pointed out, however, that "marine systems are now approaching the physical limitations of the inland waterways system."

Bottom of the tunnel stern of a river towboat, showing rudders, propellers and Kort nozzles



Types and Sizes of Barges

Four types of barges are employed: (1) open hopper, (2) covered hopper, (3) deck, and (4) tank. Based on a study of barges in use on the Mississippi River System and the Gulf Intracoastal Waterway, forty-seven type-and-size categories have been recognized, the size groupings being based on the lengths and widths of the barges.

Open hopper barges, which can be used for all types of bulk solid cargoes, dominate the field, accounting for 44 percent of the aggregate tonnage capacity of all barges operating on the inland waterways. Covered hopper barges account for one-fourth of the total ton-

nage capacity, and tank barges for 22 percent. Deck barges make up 8 percent of the combined capacity.

To improve the economy of barge transportation the hulls of the barges are shaped to reduce drag. In some cases, however, barges are built to be assembled into integrated tows. These barges, lashed together, form a tow presenting an underwater configuration similar to that which would be afforded by a single vessel. Such a design calls for continuous use of the barges in integrated arrangement, as a departure from this arrangement introduces a drag element greater than if the barges were individually designed to minimize friction. A barge built square on both ends for use in the middle of an integrated tow is particularly unwieldy to handle as a separate unit. The integrated tow design is especially adapted for the carriage of petroleum products and chemicals in tank barges.



OPEN HOPPER BARGES

TYPE	LENGTH FEET	BREADTH FEET	DRAFT FEET	CAPACITY TONS
STANDARD	175	26	9	1000
JUMBO	195	35	9	1500
SUPER JUMBO	250-290	40-52		2500-3000



COVERED HOPPER BARGES

TYPE	LENGTH FEET	BREADTH FEET	DRAFT FEET	CAPACITY TONS
STANDARD	175	26	9	1000
JUMBO	195	35	9	1500



INTEGRATED CHEMICAL AND PETROLEUM BARGES

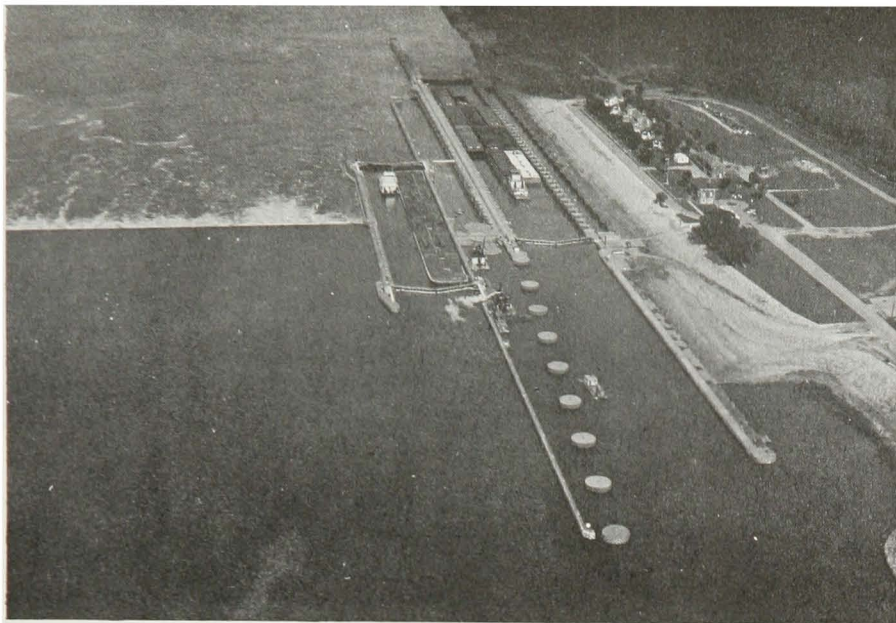
LENGTH FEET	BREADTH FEET	DRAFT FEET	CAPACITY TONS
150-300	50-54	9	1900-3000



TOWBOATS

LENGTH FEET	BREADTH FEET	DRAFT FEET	HORSEPOWER
65-160	24-50	5-9	300-7000

Predominant barge and tow types. The towboat drawing shows plainly the towing knees used in pushing the tows. The pilothouse roof gives an indication of the electronic gear used, including radar and local and distant airwave communications



Old and new, both in use. Dam 52, 2,998 feet long, includes a navigable chanoine wicket pass of 1,248 feet. The 600-foot lock was opened in 1928. The 1,200-foot lock, a temporary structure, was opened for use in December 1969

Barge and Tow Sizes on the Ohio River

A decided trend has been evident on the Ohio River toward larger barges, larger tows, and more powerful towboats. Downriver from Huntington on the order of two-thirds of the barges now in use are jumbos (195 feet by 35 feet with a capacity of 1,500 tons), about one-fourth are integrated barges (150 to 300 feet long, 50 to 54 feet wide, and with capacities of 1,900 to 3,000 tons), and most of the remainder are standard barges (175

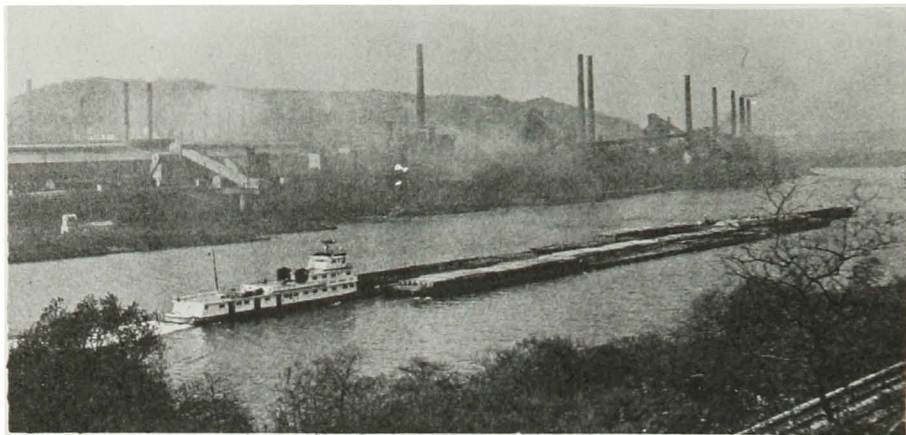
feet by 26 feet and with a capacity of 1,000 tons). Up-river from Huntington the proportion is somewhat different, jumbos accounting for about half of the total number, standards for about 30 percent, and integrateds for most of the remainder. As standard barges are retired from service they are generally being replaced by jumbos.

Tows vary in size, the average number of barges per tow being about eight. Coal tows of twenty to twenty-four standard barges or fifteen jumbo barges are frequently seen, while some tows may consist of a single barge. Mixed tows, including barges of different sizes, are commonly encountered.

Launching of the towboat Bill Carneal at Jeffboat, 22 July 1979



*Union Mechling towboat
Northern downbound with a
tow of varied products past the
Jones & Laughlin Steel Cor-
poration's plant at Aliquippa,
Pa.*



Structure of the Inland Waterways Industry

The inland waterways industry includes on the order of 2,000 or more carrier firms. In size these range from operators of single vessels to operators of extensive "fleets." The carriers are classified as regulated, exempt, and private. Some firms engage in more than one of these categories.

The *regulated* carriers, functioning under Interstate Commerce Commission jurisdiction, include (1) common carriers, which extend service to all shippers without distinction, and (2) contract carriers, which serve shippers under specific written contract. Many regulated carriers are subsidiaries of large companies, several of which have no direct connection with the inland waterways industry, indicating that inland waterways transportation has appeal as a profitable in-

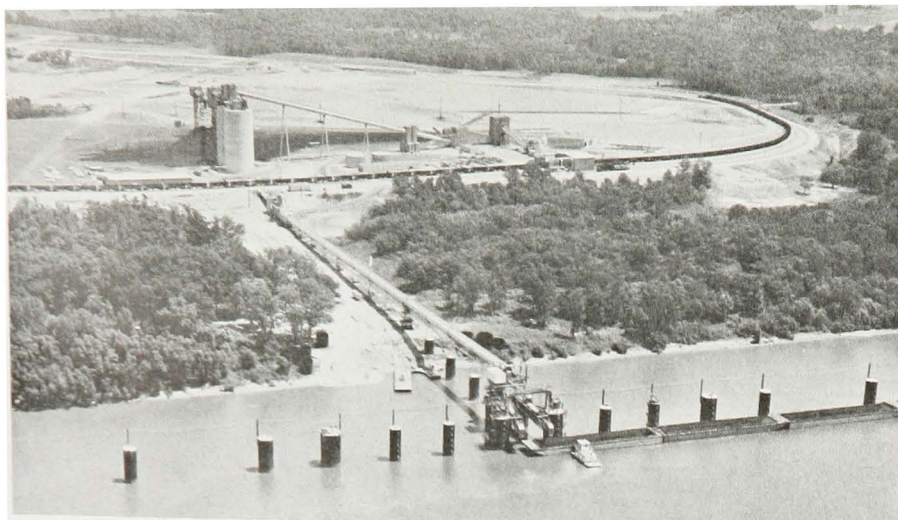
vestment. Some of the regulated carriers also conduct unregulated operations as well.

Carriage by water is *exempt* from regulation when the cargo space of the vessel or tow employed is used for carrying liquid cargoes or not more than three bulk commodities. Carriage of dry commodities is exempt, also, only if they are not mixed in the same tow with regulated commodities. (In practice, neither the three-commodity restriction nor the no-mixing rule has been much observed.) The rates charged by exempt carriers are not published, but they are often established by contract with the shipper. These carriers are not required to report revenues, operating data, or financial information.

Private carriers operate primarily for the transport of their own products, usually coal, petroleum, chemicals, or grain, but they may also carry exempt commodities for others. Many of the private carriers own no towboats of their own, but contract for towing service with regulated or exempt carriers.



Motor vessel Dennis Hendrix pushing a tow up the Ohio past Cairo



American Electric Power System's terminal on the Ohio River at Metropolis, Ill., where western coal is loaded on barges to be towed to upriver plants

Regulated traffic on the inland rivers forms a subordinate and diminishing portion of total traffic volume. In the 1962 to 1970 period, total river traffic increased from 132 billion to 204 billion ton-miles. In the same years, regulated traffic showed an irregular variation, the 32 billion ton-miles of 1962 being the top figure; the total in 1970 was 31 billion. The share of total traffic represented by regulated traffic dropped from 20.4 percent in 1962 to 15.1 percent in 1970.

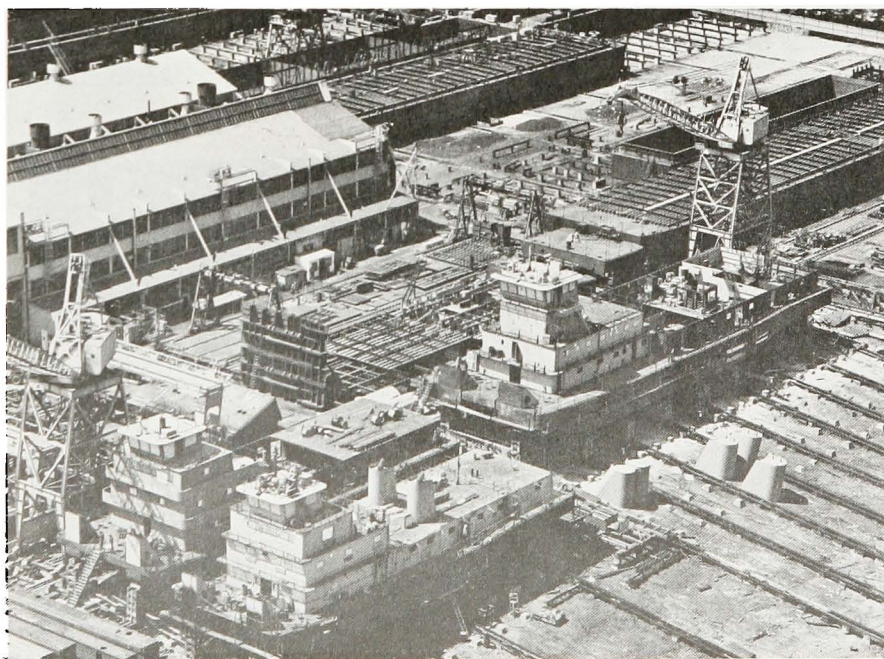
Comprehensive information on the corporate organization and size of the inland waterways carriers is not available.

A directory of the water carrier operators on the Ohio and Mississippi Rivers and their tributaries is provided in the annual revised Corps of Engineers publication, *Transportation Lines on the Mississippi River System and the Gulf Intracoastal Waterway* (Transportation Series 4).

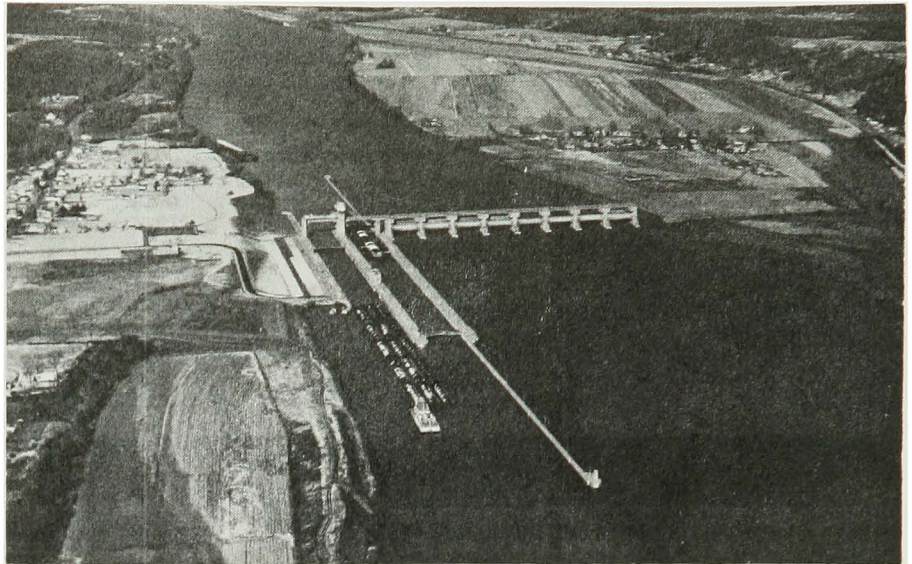
Based on a count of the 1976 issue, 180 water carrier operators are headquartered on the navigable waterways under the purview of the Corps of Engineers Ohio River Division. The following table shows the distribution of these headquarters among the Division's four districts and among the three operational categories:

Corps District	Operators Regulated by Interstate Commerce Commission (Common or Contract)	Exempt Carriers for Hire	Private Operators Carrying Own Commodities	Total
Pittsburgh	2	41	19	62
Huntington	1	28	12	41
Louisville	6	28	14	48
Nashville	2	12	15	29
	11	109	60	180

Construction of towboats and barges at the Dravo Corporation's Neville Island yard at Pittsburgh



Belleville Locks and Dam, at time of high water on the Ohio River, 11 December 1978. The normal lift of the locks is twenty-two feet, but here the gates are open to allow flow-through of the river



Life on the River

Historically, the life of the river boatman was a rough one, summed up in the mind's eye in the rugged, brawling life of Mike Fink, "king of the battling boatmen" of keelboat days.

Life on the river continues a thing apart, but it has been altered and regularized as equipment and procedures have evolved through the years and water haulage of commodities has been forced into the mold of modern business efficiency.

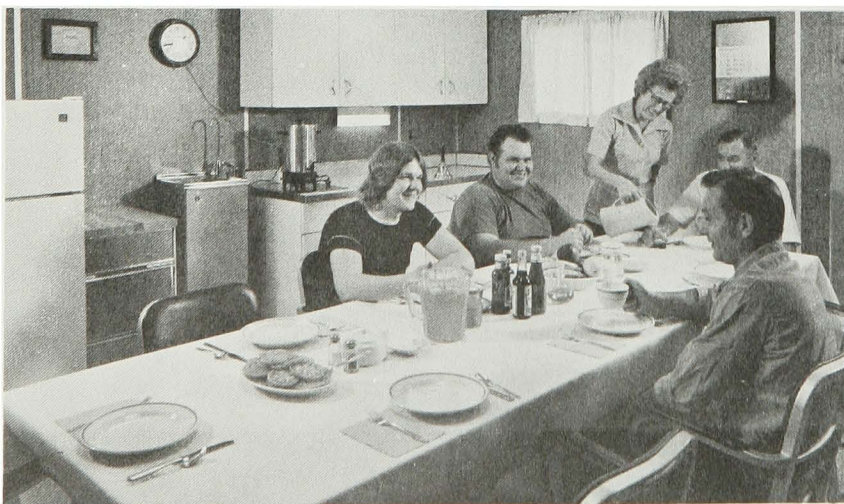
Towing employees are subject to the Fair Labor Standards Act for purposes of minimum wages, but they are exempted from the provisions relating to maximum hours and overtime. Crews engaged in line-haul operations normally work an eighty-four-hour week (twelve hours a day), in six-hour shifts. Then they have time off from work with full pay, to make up for their periods of continuous river duty.

The size of a towboat's crew is governed by the size

and power of the boat, the degree of automation, the size of the tow, and the waterway on which it is operating. Whatever the size, two working crews must be on board at all times. The crews usually stay on the job from the time the boat leaves its home port until it returns, though crew changes are sometimes made en route. Overall, some 80,000 employees work aboard the inland waterways carrier fleet, providing three or four crews for each towboat.

Living conditions are recognized as important to operating efficiency. As described in *Big Load Afloat*, a publication of Amercian Waterways Operators, Inc.: "Four meals are served every day. Laundry service is provided. Crew quarters are usually set apart from noisier parts of the vessels, and in some cases are soundproofed. . . . Many crews now enjoy the advantages of air-conditioning. Television and other recreational activities are provided aboard most boats."

Laborsaving equipment with safety features make work easier and safer than on the steamboats and keelboats of preceding eras of river commerce.



Four meals a day are served in the messroom of a river towboat

III. Future of Ohio River Navigation

Our review of the development of the Ohio River waterway has given it the appearance of an almost living organism. It has evolved through the years, as foreseen by President Herbert Hoover, and its evolution will continue.

In looking at the future, two aspects will be presented: (1) a forecast of future traffic on the Ohio River, and (2) a view of work in progress or anticipated relating to specific features of the future physical development of the waterway.

Projections of Waterborne Traffic

Planning for future improvement of the Ohio River waterway calls for as close an estimate as possible of prospective future traffic potential. For this purpose

three independent studies have been undertaken under Corps of Engineers sponsorship. These follow three separate approaches and have utilized the services of three qualified consultants.

Two of the projection efforts deal with a shorter term period, through 1990. One of these is a commodity traffic demand forecast based on analysis of historical commodity flows, assuming that there will be no additional impediments to free traffic flow.

The second shorter term projection has been developed through a highly-structured survey of all waterway shippers. This approach has the advantage of making available the insights of waterway users themselves as to their views of the future.

Preliminary results of the short-term commodity traffic forecasts indicate that navigation demands on the Ohio River basin navigation system will increase significantly through 1990. They show that traffic may be expected to increase to possibly 340 million tons by 1990, a 70 percent increase over 1976 levels, an average annual gain of about 5 percent. The forecasts indicate

Graph showing waterborne traffic for the Ohio River basin for coal and for all commodities combined for the period 1950 to 1975 and demand projections to 1990 based on two study procedures

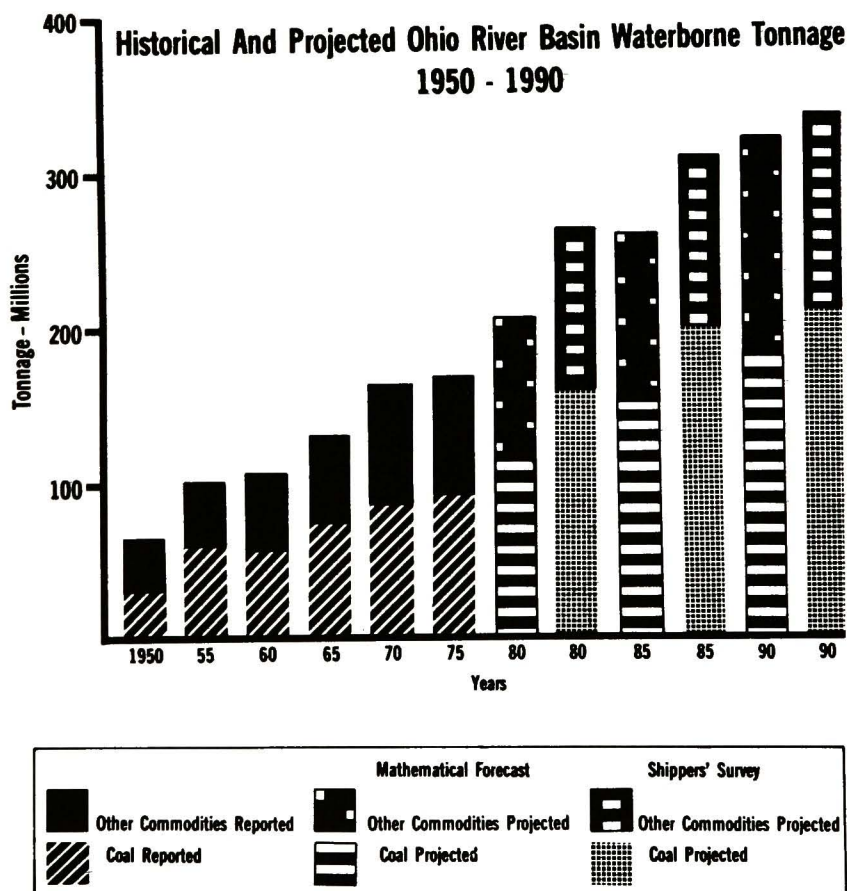


TABLE I
SUMMARY OF PLANS

Plan No.	Brief Plan Description	Construction Cost	Physical Lock Capacity (tons) ^{1/}	Significant Features
1	Continue operation, maintenance and rehabilitation of existing L&D 52, 53 to provide for a 50-year project life.	\$150,000,000	105,000,000 117,000,000	Limitation on future waterway movements resulting in increased transportation costs.
2	Major rehabilitation of existing dams at 52, 53 and construction of 2-110 x 1200 foot locks	\$300,000,000	176,000,000 249,000,000	Potential navigation delays during construction. Short term impacts to aquatic habitat of the immediate area.
3	Replacement of L&D 52, 53 with a singular dam and 2-110 x 1200 foot locks at Mound City, Illinois.	\$370,000,000 \$180,000,000 2/	199,000,000	Potential for major environmental impacts to certain riverbank and low-lying areas. Opportunity for hydroelectric development.
4	Replacement of L&D 52, 53 with a singular dam and 2-110 x 1200 foot locks near Joppa, Illinois; placement of wing dikes downstream of new dam.	\$550,000,000 \$120,000,000 2/	\$198,000,000	Potential for major environmental impacts to certain riverbank and low-lying areas. Opportunities for hydroelectric development.
5	Replacement of L&D 52, 53 with new structures just downstream of the existing projects; the structures would include 2-110 x 1200 foot locks.	\$390,000,000	176,000,000 249,000,000	Potential hazards to navigation during construction and operation. Short-term environmental impacts to aquatic habitat of the immediate area.
6	Dismantlement of L&D 52, 53; pavement of wing dikes and channel excavation to provide open river navigation conditions year-round up to Smithland L&D	\$490,000,000	Not Applicable	Potential increase in frequency of flooding in low-lying areas with associated land uses and environmental impacts to aquatic habitats. Eliminates lockage requirements.

1/ 1976 Fleet Conditions.

2/ Construction Cost of Hydroelectric Plant.

A tabulation of options considered in The Lower Ohio River Navigation Study. Reproduced from a public information brochure issued by the Louisville District

that the larger part (60 percent) of the projected tonnage will consist of coal and coke, followed by aggregates (11 percent), petroleum fuels (8 percent), chemicals and chemical fertilizers (5 percent), and other commodities (16 percent).

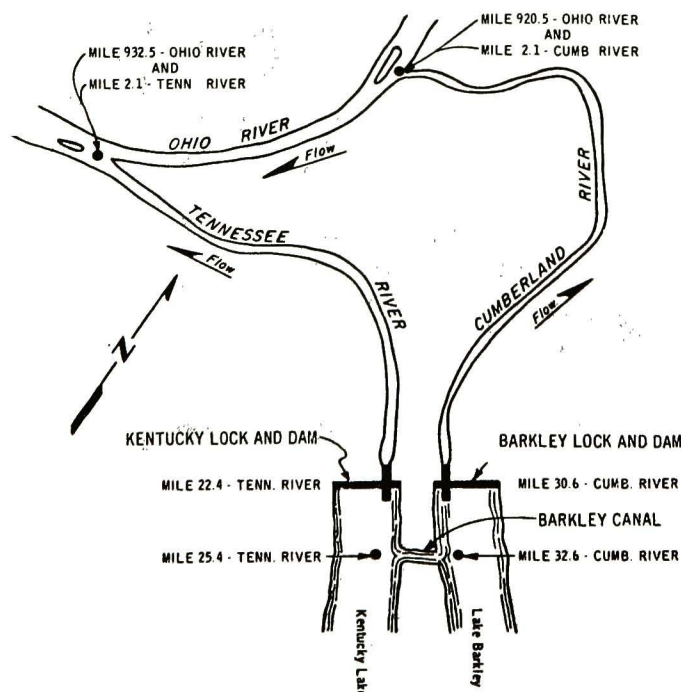
The third traffic forecast is a longer term projection, addressing the period through 2040. The study involves a detailed analysis of potential supplies, potential demands, modal-split characteristics, and the economic and institutional factors affecting production, consumption, and modal choice. This effort is the most comprehensive of the three projection procedures, addressing supply and demand constraints

on the one hand and the competitive aspects of the overall transportation system on the other. As of mid-1979 this study is still in progress.

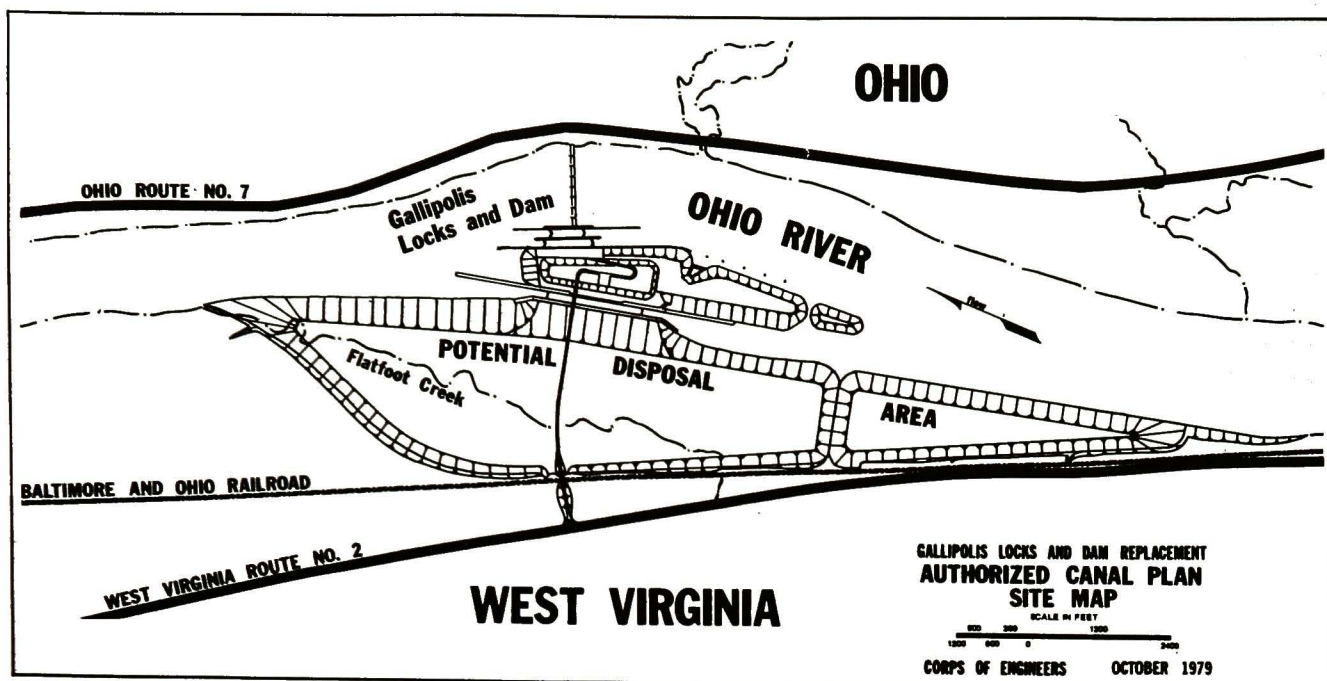
Work in Progress or Planned

Construction of Smithland Locks and Dam, at River Mile 918.5, replacing original lock and dam structures 50 and 51, is the latest feature of the Ohio River Modernization Program. Building of the project was begun in 1971 and completion is expected in 1980.

The building of the Tennessee-Tombigbee Waterway, connecting the north-flowing Tennessee River and the south-flowing Tombigbee River, was begun in 1972 and is scheduled for completion in 1986. Construction of the 40-mile-long divide section of the



A diagram included in a Corps information circular as an aid in understanding the lower Cumberland River navigation problem



A generalized delineation of one of several plans developed in connection with the Gallipolis Locks and Dam replacement study

waterway, connecting with the Pickwick pool of Tennessee River, is the responsibility of the Ohio River Division of the Corps of Engineers. The waterway will provide a new and shorter water route between the Ohio River basin and the eastern portion of the Gulf Coast.

Tennessee Valley Authority is building a 110- by 1,000-foot lock at Pickwick Landing Lock and Dam, to be added to the existing 110- by 600-foot lock. This work is to be completed in 1984.

A study is currently in progress under the Modernization Program to determine the modifications which may be needed in the existing navigation system in the lower sixty-one miles of the Ohio River. This takes in the reach from the mouth of the Cumberland River (at Smithland) to the junction with the Mississippi (at Cairo), and includes the mouth of the Tennessee (at Paducah). The Modernization Program has contemplated replacement of the navigable low-lift lock and dam structures 52 and 53 with a high-lift structure, designated Mound City Locks and Dam, which would be located at River Mile 974.2.

This project was approved in 1963, but substantial delay is anticipated in a decision concerning its execution. For this reason a temporary 1,200-foot lock has been added at Lock and Dam 52 and a temporary 1,200-foot lock is being built at Dam 53. The structural stability of Dams 52 and 53 for long-term use is under examination, and the outcome of this study will be a major consideration in determining whether these locks and dams should be replaced by the Mound City project or retained and improved.

Two projects which were included in the original 9-foot navigation system as completed in 1929 are under study for improvement. These are Emsworth and Dashields, the two lock and dam structures farthest up the Ohio. Both are high-lift concrete structures which in 1929 had already replaced the navigable low-lift wooden wicket structures 1 to 3 (built in the 1877 to 1907 period). Montgomery Locks and Dam, completed in 1936 to replace the original low-lift navigable dams 4, 5, and 6, is also aging and must be considered for replacement with a new and more efficient facility.

A replacement study is in progress for Gallipolis Locks and Dam, built in the 1935 to 1937 period to replace three Ohio River and three Kanawha River lock and dam structures. Advanced engineering and design studies were authorized by Congress in 1976 for a single replacement lock in a bypass canal and major rehabilitation of the existing dam. These studies are scheduled for completion in 1980.

Improvement of several of the canalized Ohio River tributaries is being investigated. These include the Monongahela, Allegheny, Kanawha, Green, and Cumberland Rivers.

A feasibility study for navigation on the Monongahela River is in progress which will point out the problems and needs of continued navigation on the entire river. It is expected that the feasibility report will ultimately result in authorization of the building of Grays Landing Lock and Dam to replace existing Lock and Dam 7, the building of a replacement lock at Point

Marion Lock and Dam, and establishment of a general program for replacement of Locks and Dams 2, 3, and 4. Rehabilitation of structures may be required in advance of replacement in some instances to assure continued satisfactory functioning. Such work has been in progress at Lock and Dam 3 since 1978 and is expected to be completed in 1980.

On the Allegheny River rehabilitation is anticipated at Lock and Dams 2, 3, and 4.

A feasibility study for the replacement or modernization of Winfield Locks and Dam on the Kanawha River was begun in 1974. Priority has since been assigned to the Gallipolis Locks and Dam replacement study, but early resumption of the Winfield study is expected.

Current study of Green River navigation thus far favors the no-change alternative, involving continued operation and maintenance of the 9-foot navigable depth on the lower course (103 miles) of the river.

As brought out in the section of this booklet entitled *Coordinating Two Rivers*, the opening of Barkley Canal in 1966 provided for interchange traffic movement between the Cumberland and Tennessee Rivers

above the close-by Barkley and Kentucky Dams. Because of unfavorable operating conditions along the Cumberland River below Barkley Dam, most of the Cumberland River traffic moving in either direction has since been using the lower Tennessee route. Investigations are in progress to determine whether conditions on the Cumberland below Barkley Dam can be improved adequately or whether traffic would be better served by concentrating improvements on Kentucky Dam and the lower Tennessee.

The Big Sandy River is under study for the possible reestablishment of navigation on the middle and upper segments of the main stream, and, as well, on the Levisa and Tug Forks, where extension beyond the former limits is being considered.

Studies for potential 12-foot navigation on the Ohio River were undertaken in the late 1940s and early 50s, but no recommendation was submitted to Congress. The studies have been classified since 1954 as "deferred," and there are no present plans for their resumption.

Information Sources

Illustrated booklets covering *Water Resources Development by the U. S. Army Corps of Engineers* are issued, by states, at two-year intervals. The Ohio River Division is responsible for: Ohio, West Virginia, Kentucky, Tennessee, and Indiana. Copies may be obtained without cost from the Ohio River Division Office at Cincinnati or from the District Offices, as listed on the inside front cover of this booklet.

Histories of the four districts composing the Corps' Ohio River Division have been prepared by Leland R. Johnson, Ph.D., a consulting historian. The histories for the Huntington, Louisville, and Nashville Districts have been published and are available for reference at the respective District offices or at libraries. Copies of these histories are also available for purchase. The history of the Pittsburgh District has been completed

and is in process of publication.

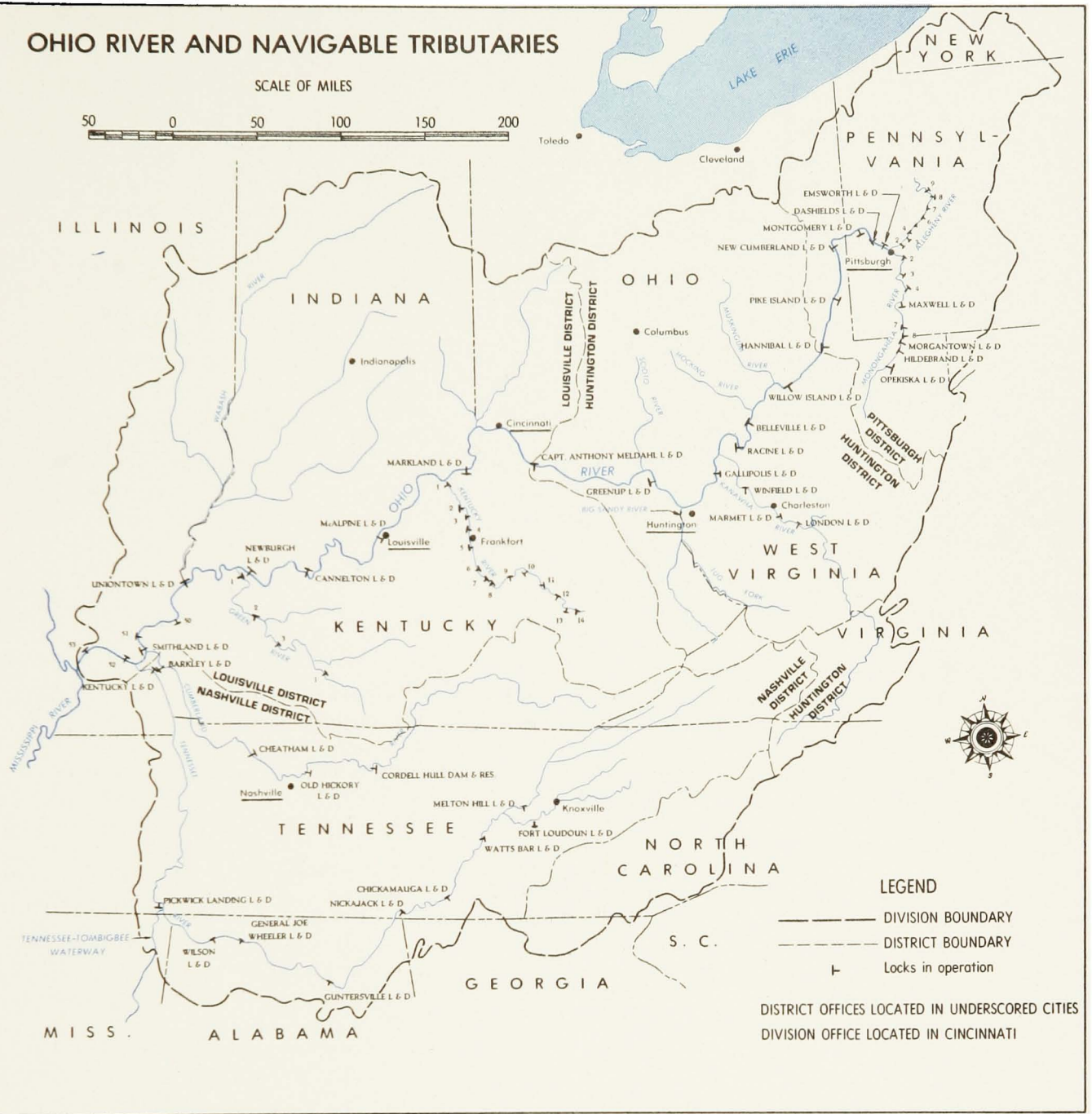
Maps and charts for sale by the Corps of Engineers Ohio River Division are listed in *Division Bulletin No. 1*, which is reissued each year in revised form. Other maps, from published Corps studies, are available upon specific request, but these are not available for general sale, and a listing of them would not be feasible.

Many sources have been consulted in the preparation of this commemorative booklet. Any Corps office will be glad to help inquirers in finding additional information on any of the subjects treated herein. The Navigation/Economics Branch, Huntington District, Corps of Engineers, P. O. Box 2127, Huntington, West Virginia 25721, was responsible for the assembling of the material used in the booklet and can assist in developing fuller information.

All Corps installations have Public Affairs Offices whose function is to help the public in obtaining any desired information concerning Corps activities.

OHIO RIVER AND NAVIGABLE TRIBUTARIES

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Commemorative Stamp

The Ohio River Canalization stamp was issued 19 October 1929. First day sale took place at Cairo, Ill., Evansville, Ind., Louisville, Ky., Cincinnati, Ohio, Wheeling, W. Va., and Homestead and Pittsburgh, Pa. The stamps were printed in carmine rose on unwatermarked paper.

*Since the stamp was commemorative of the canalization of the Ohio, it may seem a little odd that the subject selected for the picture was Locks and Dam 5 on the Monongahela (built 1907-10). Monongahela towboat pilot and author Richard Bissell states in his book, *The Monongahela*, that the photograph on which the engraving was based was taken on 4 October 1920.*

The stamp is reproduced through the courtesy of the Smithsonian Institution.